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ASSESSMENT OF NEWFOUNDLAND AND LABRADOR SNOW CRAB

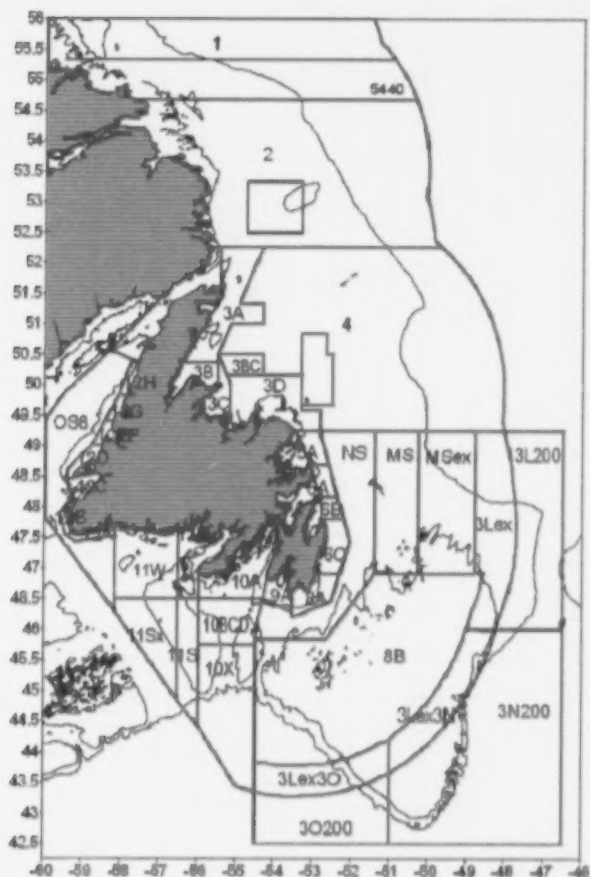


Figure 1: Newfoundland and Labrador Snow Crab Management Areas (CMAs). Blue boxes show trawling & gill-netting closures.

Context

Snow crab (*Chionoecetes opilio*) occur over a broad depth range in the Northwest Atlantic from Greenland to the Gulf of Maine. Distribution in waters off Newfoundland and southern Labrador is widespread and continuous.

Crab harvesters use fleets of baited conical traps. The minimum legal size is 95 mm carapace width (CW). This regulation excludes females from the fishery while ensuring that a portion of the adult males in the population remains available for reproduction.

Total Allowable Catch (TAC) management was initiated in the late 1980's. This led to the development of multiple TAC-controlled management areas (Fig. 1) with about 3200 license holders across several vessel fleets under enterprise allocation in 2011. All fleets have designated trap limits, quotas, trip limits, fishing areas within divisions, and differing seasons.

Stock status is assessed annually for inshore and offshore areas (where applicable) within each NAFO Division. A vessel monitoring system (VMS) was fully implemented in the offshore fleets in 2004.

Resource status is evaluated based on trends in fishery catch per unit of effort (CPUE), exploitable biomass indices, recruitment prospects, and mortality indices. Data are derived from multi-species bottom trawl surveys in Div. 2HJ3KLNOP4R, DFO inshore trap surveys in Div. 3KLPs, fishery data from logbooks, observer catch-effort data, industry-DFO collaborative trap survey data, as well as biological sampling data from multiple sources.

A meeting of the Regional Advisory Process (RAP) was held Feb. 21-24 and Feb 28-Mar 1, 2012 in St. John's, NL to assess the status of the snow crab resource. Participants included DFO scientists, fisheries managers, and representatives from industry, the Provincial and Nunatsiavut governments and academia.

SUMMARY

- **Total landings** increased by 22% from 44,000 t in 2005 to 53,500 t in 2009, and since changed little, at 53,000 t in 2011, with an increase in the South (Div 3LNOPs) and a decline in the North (2J3K).
- The multi-species trawl surveys indicate that the **exploitable biomass** has declined since 2009.
- **Recruitment** has recently declined and is expected to decline further in the short term.
- **Long-term recruitment** prospects are unfavourable due to a warming oceanographic regime.

Division 2H

- **Landings** declined by 95% from 190 t in 2007 to 10 t in 2011. The TAC has not been taken for three consecutive years.
- Fishery data are very limited. However, **CPUE** has declined steadily since 2006.
- The **exploitable biomass** is very low. The post-season trawl survey exploitable biomass index decreased by 94% since the 2006 peak.
- **Recruitment** has decreased since 2004 and is expected to be low over the next several years. There were no pre-recruit males captured in the 2010 or 2011 post-season trawl surveys.
- **Long-term recruitment** prospects are poor. There have been no small (<80mm carapace width) males captured in the post-season trawl surveys since 2001.

Division 2J

- **Landings** decreased by 21% since 2008 to 1,900 t while **effort** increased by 52%.
- **CPUE** most recently peaked in 2008 and has since decreased by half.
- The **exploitable biomass** has decreased in recent years. The post-season trawl survey exploitable biomass index peaked in 2006 and has since decreased by half.
- **Recruitment** has recently been in decline and is expected to remain low in the short term. The post-season trawl survey pre-recruit index decreased sharply in 2005 and has since fluctuated without trend.
- **Long-term recruitment** prospects are unfavourable due to a warming oceanographic regime.
- The **exploitation rate index** changed little in the past three years. The **pre-recruit fishing mortality rate index** has remained low in recent years, but increased to its highest level since 2004 during 2011.
- Maintaining the current level of fishery removals would likely increase the **exploitation rate** in 2012.

Division 3K Offshore

- **Landings** peaked at 12,600 t in 2009 but decreased by 35% to 8,200 t in 2011. The TAC was not achieved in the past 2 years. **Effort** changed little until it increased by 71% in 2009 before decreasing by 15% in 2010 and increasing marginally in 2011.
- **CPUE** has declined sharply since 2008.
- The **exploitable biomass**, as indicated by the post-season trap and trawl survey indices, declined by more than half since 2008.

- **Recruitment** decreased in 2011 and is expected to decrease further in 2012. Prospects remain poor in the short term. Post-season pre-recruit biomass indices from both trap and trawl surveys have decreased by about 40% since 2008.
- **Long-term recruitment** prospects are unfavourable due to a warming oceanographic regime.
- The trawl survey-based **exploitation rate index** declined sharply between 2006 and 2008 and has since increased back to the 2006 level. The **pre-recruit fishing mortality rate index** increased from 2007-2011.
- Maintaining the current level of fishery removals would likely result in an increase in the **exploitation rate** and high mortality on soft-shelled immediate pre-recruits in 2012.

Division 3K Inshore

- **Landings** increased from 2,700 t in 2005 to 3,600 t in 2009, but decreased by 31% to 2,500 t in 2011. The TAC was not taken in 3 of the 5 management areas in 2011. **Effort** has increased by 64% since 2008.
- **CPUE** increased sharply from 2005 to a record high level in 2008, but has since declined by more than half.
- The **exploitable biomass**, as indicated by the post-season trap survey index, decreased gradually between 2007 and 2010 and since changed little but there is considerable variability among management areas.
- While uncertain, **recruitment** prospects appear to have changed little and there is considerable variability among management areas.
- The trap survey-based **exploitation rate index** increased sharply in 2010 and then returned to the 2007–2009 level in 2011. Data are insufficient to estimate the **pre-recruit fishing mortality rate index**.
- Maintaining the current level of removals would likely have little effect on the **exploitation rate** in 2012. However, it would likely result in increased wastage of soft-shelled immediate pre-recruits in some management areas in 2012.

Division 3LNO Offshore

- **Landings** decreased from 24,500t in 2007 to 22,000t in 2009 but since increased to 26,000t. **Effort** increased slightly in 2011 following a 2008-2010 decrease.
- **VMS-based CPUE** declined to its lowest level in 2008, but has since increased to the long-term average.
- Opposing survey trends create uncertainty about the **exploitable biomass**. The trawl survey index decreased by 34% since 2009 while the trap survey index increased by 21%.
- **Recruitment** has recently peaked and will likely decrease over the short term.
- **Long-term recruitment** prospects are unfavourable due to a warming oceanographic regime.
- The **exploitation rate index** increased in 2011 following a sharp decrease from 2008-2010 while the **pre-recruit fishing mortality rate index** has remained near its lowest level during the past three years.
- Maintaining the current level of removals would have an uncertain effect on the **exploitation rate** in 2012.

Division 3L Inshore

- **Landings** increased by 19% from 6,100 t in 2005 to 7,300 t in 2010 and decreased slightly to 7,100 t in 2011. **Effort** increased by 24% from 2008-2010 but decreased slightly in 2011.
- **CPUE** has remained at the long-term average for the past three years.
- The post-season trap survey index suggests that the **exploitable biomass** has changed little over the past 6 years.
- Overall, **recruitment** prospects have recently improved.
- The trap survey-based **exploitation rate index** decreased slightly in 2011. Data are insufficient to estimate a **pre-recruit fishing mortality rate index**.
- Maintaining the current level of fishery removals would likely result in little change in the **exploitation rate**, but may increase mortality on soft-shelled immediate pre-recruits in some management areas in 2012.

Subdivision 3Ps Offshore

- **Landings** almost doubled from 2,300 t in 2006 to 4,300 t in 2011. Meanwhile, **effort** increased by 56 % since 2008.
- **CPUE** increased from 2005-2009 and has since declined slightly.
- The **exploitable biomass**, as indicated by both the spring trawl survey and the post-season trap survey indices, increased steadily from 2006-2009 and has since declined sharply to 2011.
- **Recruitment** has recently declined and is expected to decline further in the short term. Post-season pre-recruit biomass indices from both trap and trawl surveys declined sharply from 2009-2011.
- **Long-term recruitment** prospects are unfavourable due to a warming oceanographic regime.
- **Exploitation and pre-recruit fishing mortality rates**, as indicated by spring trawl survey indices, decreased from 2007-2009 but increased sharply to 2011.
- Maintaining the current level of fishery removals would likely result in an increase in the **exploitation rate** in 2012.

Subdivision 3Ps Inshore

- **Landings** more than tripled from 700 t in 2005 to 2,500 t in 2011. Meanwhile, **effort** declined from 2005-2010 and increased by 22% in 2011.
- **CPUE** increased steadily from 2005 to its highest level since 1996 in 2010 and decreased marginally in 2011.
- The **exploitable biomass**, as indicated by the post-season trap survey index, increased substantially between 2006 and 2010 and decreased in 2011.
- **Recruitment** decreased in 2011 and is expected to decrease further in the short term.
- The post-season trap survey-based **exploitation rate index** changed little during 2008-2011. Data are insufficient to estimate a **pre-recruit fishing mortality rate index**.
- Maintaining the current level of fishery removals would likely result in an increase in the **exploitation rate** in 2012.

Division 4R Offshore

- **Landings** declined by 83% from 190 t in 2007 to a historical low of 30 t in 2010, but increased to 150 t in 2011. **Effort** increased by a factor of four in 2011 following the historical low in 2010. The TAC has not been taken since 2002.
- **CPUE** declined from 2004 to a historical low in 2009, increased sharply in 2010, and fell to the 2009 level again in 2011.
- The **exploitable biomass** remains low.
- **Recruitment** has been low in recent years and prospects are uncertain.
- Data are insufficient to calculate **exploitation rate** and **pre-recruit fishing mortality rate indices**.
- The effect of maintaining the current level of removals on the **exploitation rate** in 2012 is unknown.

Division 4R Inshore

- **Landings** declined sharply by 80% from 950 t in 2003 to a historical low of 190 t in 2010 and increased to 450 t in 2011. **Effort** declined by 95% from 2004 to 2010 and doubled in 2011. The TAC has not been taken since 2003.
- **CPUE** declined from 2002-2007 and has since varied without trend below the long-term average.
- The post-season trap survey **exploitable biomass index** changed little from 2005-2009 but has increased greatly in the past two years.
- **Recruitment** has recently increased and short-term prospects remain promising in most management areas.
- The post-season trap survey-based **exploitation rate index** decreased from 2007-2010 but increased sharply in 2011. Data are insufficient to estimate a **pre-recruit fishing mortality rate index**.
- Increasing fishery removals in 2012 would likely have little effect on the **exploitation rate** but may increase mortality on soft-shelled immediate pre-recruits in some management areas.

BACKGROUND

Species Biology

The snow crab life cycle features a planktonic larval period, following spring hatching, involving several stages before settlement. Benthic juveniles of both sexes molt frequently, and at about 40 mm carapace width (CW) (~ 4 years of age) they may become sexually mature.

Crabs grow by molting, in spring. Females cease molting after sexual maturity is achieved at about 40-75 mm CW and so do not contribute to the exploitable biomass. However sexually mature (adolescent) males may continue to molt annually until their terminal molt, when they develop enlarged claws (adults), which enhances their mating ability. Males may molt to adulthood within a size range of about 40-115 mm CW, and so only a portion of any cohort will recruit to the fishery at 95 mm CW (~ 8 years of age).

Snow crab is a highly stenothermal species and temperature has a profound effect on production, early survival and subsequent recruitment to fisheries (Foyle et al. 1989, Dawe et al.

2008, Boudreau et al. 2011). A cold oceanographic regime during early life history is associated with increased fishery CPUE and survey biomass indices 6–8 years later. Low temperature also promotes relatively small size at terminal molt, resulting in an increased portion of crabs failing to recruit to the fishery. However, the positive effect of a cold thermal regime on early survival is clearly stronger than the negative effect on size-at-terminal molt.

Adult legal-sized males remain new-shelled with low meat yield throughout the remainder of the year of their terminal molt. They are considered to be pre-recruits until the following year when they begin to contribute to the exploitable biomass as older-shelled adults. Males may live about 6–8 years as adults after the terminal molt.

Snow crabs undertake an ontogenetic migration from shallow cold areas with hard substrates to warmer deeper areas with soft substrates. Large males are most common on mud or mud/sand, while smaller crabs are common on harder substrates. Snow crab diet includes fish, clams, polychaete worms, brittle stars, shrimp, snow crab, and other crustaceans. Predators include various groundfish, other snow crabs, and seals.

The Fishery

The fishery began in Trinity Bay (Management area 6A, Fig. 1) in 1967. Initially, crabs were taken as gillnet by-catch but within several years a directed trap fishery developed in inshore areas along the northeast coast of Div. 3KL. The minimum legal mesh size of traps is 135 mm, to allow small crabs to escape. Under-sized and new-shelled males that are retained in the traps are returned to the sea and an unknown proportion dies.

Until the early 1980's, the fishery was prosecuted by approximately 50 vessels limited to 800 traps each. In 1981 fishing was restricted to the NAFO Division adjacent to where the license holder resided. During 1982–1987 there were major declines in the resource in traditional areas in Div. 3K and 3L while new fisheries started in Div. 2J, Subdiv. 3Ps and offshore Div. 3K. A snow crab fishery began in Div. 4R in 1993.

Licences supplemental to groundfishing were issued in Div. 3K and Subdiv. 3Ps in 1985, in Div. 3L in 1987, and in Div. 2J in the early 1990's. Since 1989 there has been a further expansion in the offshore. Temporary permits for inshore vessels <35 ft., introduced in 1995, were converted to licenses in 2003. There are now several fleet sectors and about 3200 license holders.

In the late 1980's quota control was initiated in all management areas of each division. Current management measures include trap limits, individual quotas, trip limits, fishing areas within divisions, and differing seasons. The fishery has started earlier in recent years and is now prosecuted predominately in spring, resulting in reduced incidence of soft-shelled crabs. A protocol was initiated in 2004 that results in closure of localized areas when the percent soft-shelled crabs within the legal-sized catch exceeds 20%. In Div. 3L, the closure threshold was reduced to 15% in 2009. Mandatory use of the electronic vessel monitoring system (VMS) was fully implemented in all offshore fleets in 2004, to ensure compliance with regulations regarding area fished.

Landings for Div. 2HJ3KLNOP4R (Fig. 2) increased steadily from 1989 to peak at 69,100 t in 1999, largely due to expansion of the fishery to offshore areas. They decreased by 20% to 55,400 t in 2000 and changed little until they decreased to 44,000 t in 2005, primarily due to a sharp decrease in Div. 3K where the TAC was not taken. Landings increased by 22% from 44,000 t in 2005 to 53,500 t in 2009, and since changed little, at 53,000 t in 2011, with an increase in the South (Div 3LNOPs) and a decline in the North (2J3K). Historically, most of the

landings have been from Div. 3KL. Effort has increased since the 1980's and has been broadly distributed in recent years (Fig. 3).

The fishery has been delayed in northern divisions (Div. 2J and 3K) in some years due to severe ice conditions. Late fishing seasons are believed to contribute to a high incidence of soft-shelled immediate pre-recruits in the catch. Such severe ice conditions can affect the spatial distribution of fishing effort and fishery performance. The fishery was delayed, in many areas, in 2010 due to a dispute relating to the price of crab. It was not delayed in any areas in 2011, and began in early April.

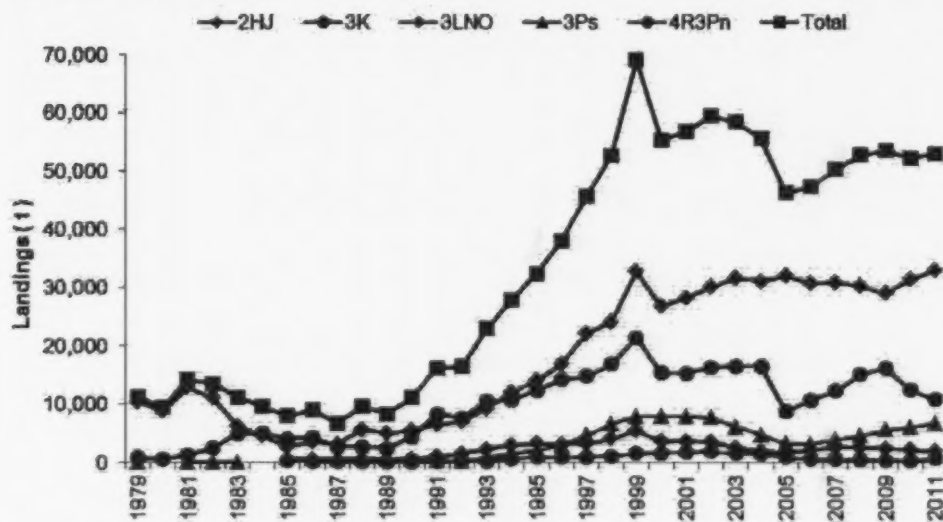


Figure 2: Trends in landings by NAFO Division and in total.

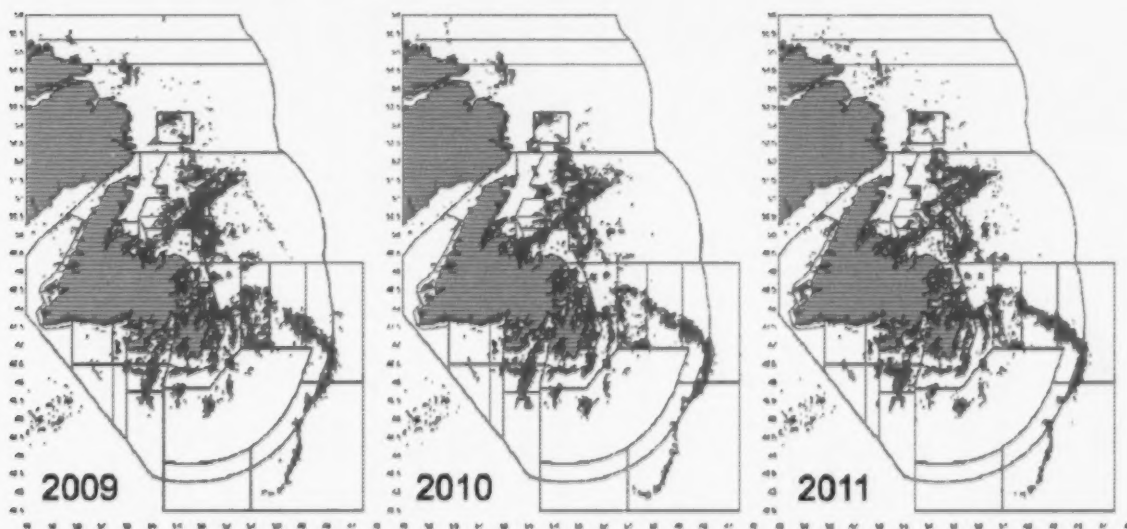


Figure 3: Spatial distribution of commercial fishing effort during 2009-2011.

ASSESSMENT

Resource status was evaluated based on trends in fishery CPUE, survey **exploitable biomass indices**, fishery **recruitment prospects** and **mortality indices**. Information was derived from multi-species bottom trawl surveys conducted during fall in Div. 2HJ3KLNO, during spring in Subdiv. 3Ps, and during summer in Div. 4R. A Campelen shrimp trawl has been used in these multi-species surveys beginning in 1995 (Div. 2HJ3KLNOs) or 2004 (Div. 4R). The fall post-season trawl survey was conducted in Div. 2H every second year from 2004-2010, and in 2011. Spring trawl surveys are considered to be 'pre-fishery' surveys, although they overlap with much of the Subdiv. 3Ps fishery in recent years. These spring surveys are thought to be less reliable than fall (post-fishery) surveys because some population components are relatively poorly sampled during spring when mating and molting take place. Information was also available from a fall Industry-DFO collaborative post-season (CPS) trap survey initiated in 2003. Fall post-season surveys provide the most recent data available for the annual RAP. Information is also utilized from DFO inshore trap and trawl surveys in Div. 3KLPs, fishery data from VMS, logbooks, and observer catch-effort data, as well as biological sampling data from multiple sources. There are multiple CPUE indices used in the assessment, but in offshore areas VMS-based CPUE is considered the most reliable due to complete coverage (excepting Div. 2HJ) and little element of human error. Bottom temperature data from DFO surveys were used to develop ocean climate indices toward inferring long-term recruitment prospects.

The resource is assessed separately for offshore and inshore areas of each division, where appropriate (Div. 3KLPs4R); there is no distinction between inshore and offshore areas in Div. 2HJ (Fig. 1). Div. 3LNO offshore is assessed as a unit because the offshore fishery is managed at that spatial scale. More data are available for offshore than inshore areas in most divisions. Trawl survey data are used only for offshore areas because these surveys have not consistently extended into inshore areas. Observer coverage and sampling has also been more extensive in offshore than inshore areas. Also, VMS is used only on offshore vessels.

Trawl survey abundance and biomass indices are calculated based on a set of "core strata" that was common to most years, especially recent years, and does not include inshore strata or deep (>730 m) slope strata that have not been regularly sampled.

Spring pre-season (Subdiv. 3Ps), summer post-season (Div. 4R), and fall post-season (Div. 2HJ3KLNO) bottom trawl surveys provide data that are used to predict changes in biomass and recruitment for the upcoming fishery in the same year (Subdiv. 3Ps) or the following year (Div. 2HJ3KLNO4R). These surveys, based on a stratified random sampling scheme, provide an index of the exploitable biomass that is expected to be available for the upcoming fishery. This exploitable biomass index is based on only adults of legal size from the spring and fall surveys, but is based on all legal-sized crabs from the Div. 4R summer survey (where chela height is not measured). This index is used together with an exploitable biomass index (all legal-sized crabs) from the CPS trap survey in offshore areas to evaluate trends in the exploitable biomass. The inshore CPS trap survey exploitable biomass index is compared with commercial CPUE and catch rates from inshore DFO trap surveys, where available (Div. 3KLPs).

Bottom trawl surveys also provide data on recruitment. Recent changes in recruitment are inferred from changes in survey biomass indices in relation to landings. Recruitment prospects for the upcoming fishery (in the next year) are inferred from biomass indices or catch rates of new-shelled legal-sized adults (immediate pre-recruits) from post-season trawl surveys. Trawl surveys also provide an index of pre-recruit biomass, based solely on adolescent (non-terminally-molted) males larger than 75 mm CW from the spring and fall surveys, but is based

on all males 76-94 mm CW from the Div. 4R summer survey. The adolescents of these groups would recruit in the short term (about 2-3 years) following the upcoming fishery. Short-term recruitment prospects are also inferred from biomass indices or catch rates of sub-legal-sized ('under-sized') males from observer at-sea sampling and post-season trap surveys. However, these males include an unknown portion of under-sized adults (terminally molted) that will never recruit.

Trawl surveys also provide abundance indices for males of all sizes. However there is little evidence of annual progression of smallest males (< 40 mm CW) to successively larger sizes from spring or fall multi-species survey size frequency data. Longer-term (ie. >3 years) recruitment prospects are inferred based on effects of ocean climate variation on early survival (Dawe et al 2008), as reflected in the relationship of biomass indices (CPUE and survey exploitable biomass indices) with ocean climate indices from 6-8 years earlier. Two thermal indices are used in each offshore area. A mean bottom temperature index is derived using fall (Div. 2J and 3K) or spring (Subdiv. 3Ps) survey data from shallow-water small crab habitat on the banks and in nearshore areas for Div. 2J (<200m), 3K (<300m) and 3Ps (<100m). The temperature index for Div. 3LNO is the Jan-Jun mean bottom temperature at 176 m, from Station 27 oceanographic monitoring station, located within the inshore branch of the Labrador Current, 10 nm off Cape-Spear, NL. The second index is a small crab habitat index, represented by the percentage of the bottom area covered by cold water. This index is derived using data from fall surveys based on temperatures <2°C in the deep warm northern areas (Div. 2J and 3K), whereas they are derived using data from spring surveys in the shallower colder southern areas, based on temperatures <0°C (Div. 3LNO) and <1°C (Subdiv. 3Ps). Best relationships were found at short lags (6 years) in the warm northern areas (Div. 2J and 3K) and at longer lags (7 and 8 years) in the cold southern areas (Subdiv. 3Ps and Div. 3LNO respectively). Relationships were found to be consistent between CPUE and survey biomass indices, so they are shown here using only the longer time series of CPUE indices.

The CPS trap survey, based on a fixed-station grid design, is more spatially limited than the trawl survey as it targets only portions of commercial fishing grounds. A set of core stations was selected from this survey for calculating catch rates (number/trap) of legal-sized adults. These core stations represented those that were common to most years, especially recent years. A stratification scheme, developed for the previous assessment, established core strata for estimating biomass indices. The survey also includes small-meshed traps, deployed on select stations, to provide data on long-term recruitment prospects.

Fishery-induced mortality is a function of the proportion of the exploitable population that is harvested and the proportion of the pre-recruit population that dies as a result of being caught and released. Trends in exploitation rate are inferred from changes in the ratio of landings to the exploitable biomass index from the most recent trap and trawl surveys. The pre-recruit fishing mortality index reflects an unknown mortality on released pre-recruits. Trends in pre-recruit fishing mortality are inferred from changes in the ratio of the estimated total catch of undersized (<94 mm CW) males (adolescents and adults) to the trawl survey biomass index of pre-recruits plus undersized (76-94 mm CW) adults from the most recent trawl survey. The total catch of under-sized males is estimated as the observed discards of under-sized males scaled to total landings. Pre-recruit fishing mortality indices were not estimated for inshore areas due to inadequate observer coverage.

The percentage (by weight) of the total catch discarded, as estimated from observer data, is interpreted as an index of wastage of pre-recruits. Mortalities on pre-recruits, including wastage, will impact short-term (about 1-3 years) recruitment. Also, mortality on small (<95 mm CW) males may adversely affect insemination of females, especially when abundance of larger

males is low. The percent discarded is not estimated for inshore areas due to inadequate observer coverage.

Overall Resource Status, Divisions 2HJ3KLNOP4R

Multi-species trawl surveys indicate that the **exploitable biomass** was highest at the start of the survey series (1995-1998, Fig. 4). It declined from the late 1990's to 2003, increased to 2008 and changed little in 2009. Most of the increase was due to recovery in the South (Div. 3LNOPs) while the North (Div. 2HJ3K) declined, as reflected in the divisional trends. The exploitable biomass has declined since 2009, reflecting continued decline in the North together with a more recent decline in the South.

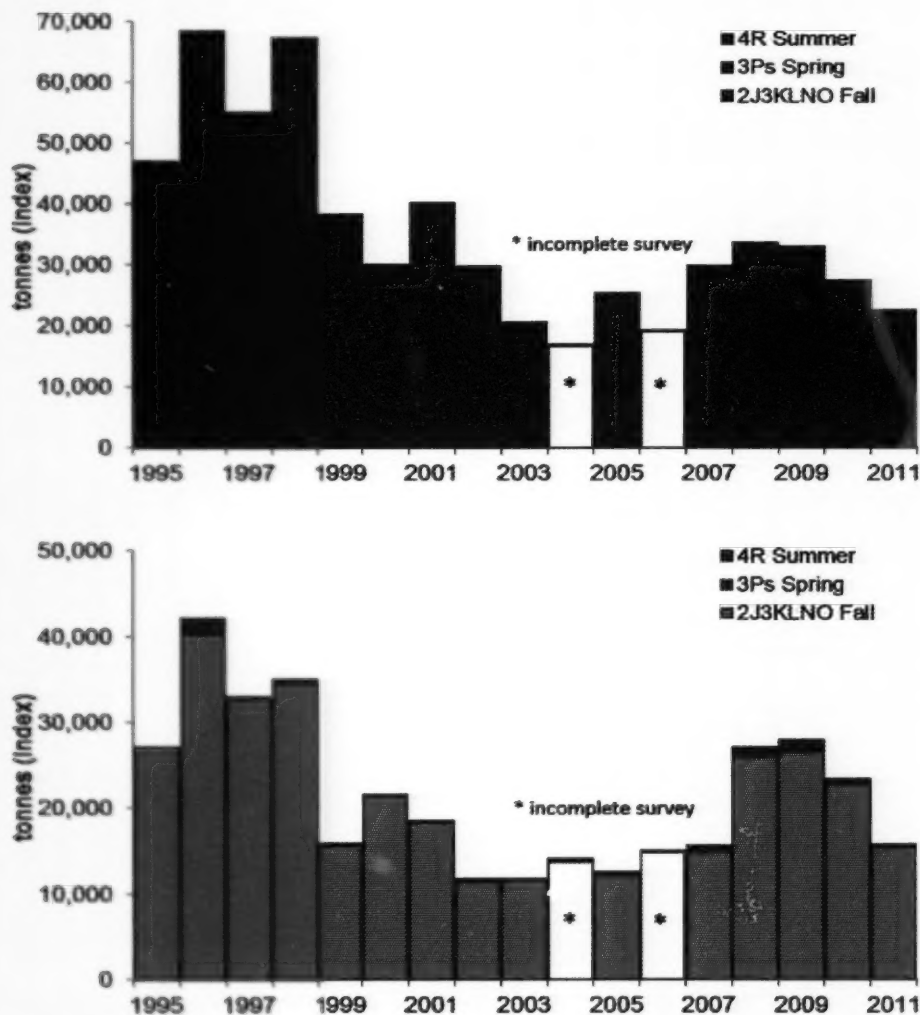


Figure 4: Trends in exploitable biomass indices (above) and pre-recruit biomass indices (below) from multi-species surveys during fall (Div. 2J3KLNO), spring (Subdiv. 3Ps) and summer (Div. 4R). Note that season-specific indices are not additive due to differences in trawl efficiency.

Recruitment increased from 2003-2008 but has recently declined and is expected to decline further in the short term. The survey biomass index of pre-recruits (Fig. 4) increased from 2007-2009 due to increases in the South (Div. 3LNOPs). It has declined in all areas since 2009. Long-term recruitment prospects are unfavourable due to a warming oceanographic regime. This is consistent with data from CPS survey small-meshed traps that show no evidence of small adolescent males progressing through size frequency distributions in most areas.

Resource Status, Division 2H

Commercial Fishery

There have been exploratory fisheries since the mid 1990's. A commercial TAC was first established in 2008 at 100 t and was changed to 70 t in 2011. (Fig. 5). Landings increased from 70-190 t during 2005-2007 and subsequently declined by 95% to 10 t in 2011. The TAC has not been taken for three consecutive years.

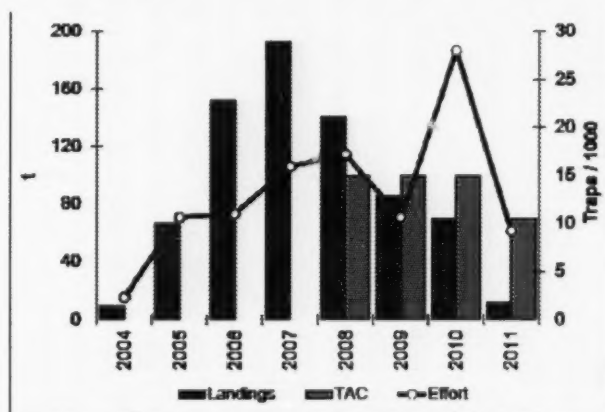


Figure 5: Trends in TAC, landings, and fishing effort in Div. 2H.

Fishery data are very limited. There are few participants, not all vessels carry VMS, and logbook return rates are low. However, CPUE has declined steadily since 2006 (Fig. 6).

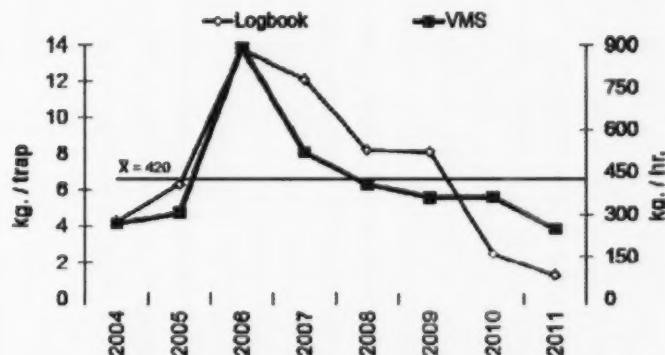


Figure 6: Trends in Div. 2H commercial CPUE. Horizontal line indicates the average based on VMS. The 2010 logbook CPUE value is based on limited data.

Biomass

The **exploitable biomass** is very low. The post-season trawl survey exploitable biomass index decreased by 94% since the 2006 peak (Fig. 7).

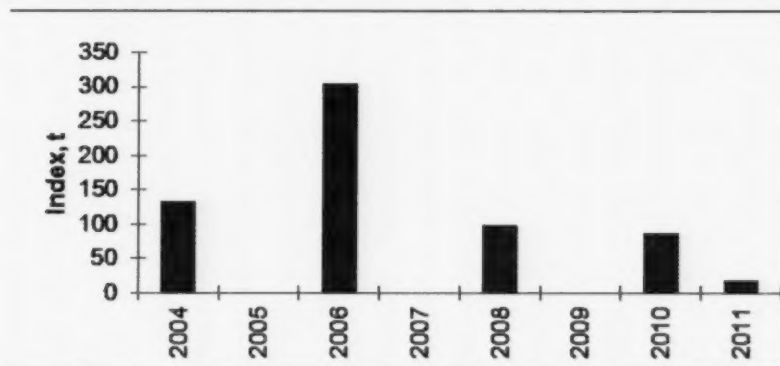


Figure 7: Trends in the Div. 2H exploitable biomass index based on the post-season trawl survey.

Recruitment

Recruitment has decreased since 2004 and is expected to be low over the next several years. There were no pre-recruit males captured in the 2010 or 2011 post-season trawl surveys (Fig. 8). Long-term recruitment prospects are poor. There have been no small (<60mm carapace width) males captured in the post-season trawl surveys since 2001.

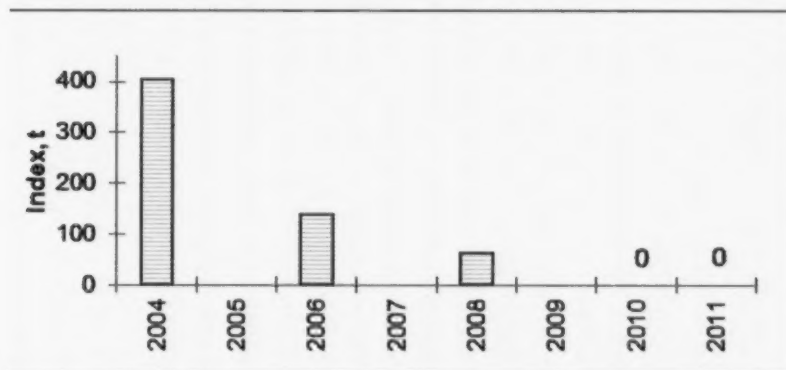


Figure 8: Trends in the Div. 2H pre-recruit biomass index based on the post-season trawl survey.

Mortality

Data are insufficient to calculate annual values for the exploitation rate index due to the variable frequency of the survey. A pre-recruit fishing mortality rate index cannot be calculated due to the absence of observer data.

Resource Status, Division 2J

Commercial Fishery

Landings (Fig. 9) peaked in 1999 at 5,400 t, decreased sharply to 3,700 t in 2000 and changed little to 2002, before declining to 2005. They increased by 60% from 1,500 t in 2005 to 2,400 t in 2008 and then decreased by 21% to 1900 t in 2011. **Effort** increased from 2000 to a record high level in 2002-2004. It decreased sharply in 2005, declined further to 2008, and subsequently increased by 52% to 2011.

The 2011 fishery was concentrated in Hawke and Cartwright channels, as it was in the previous five years.

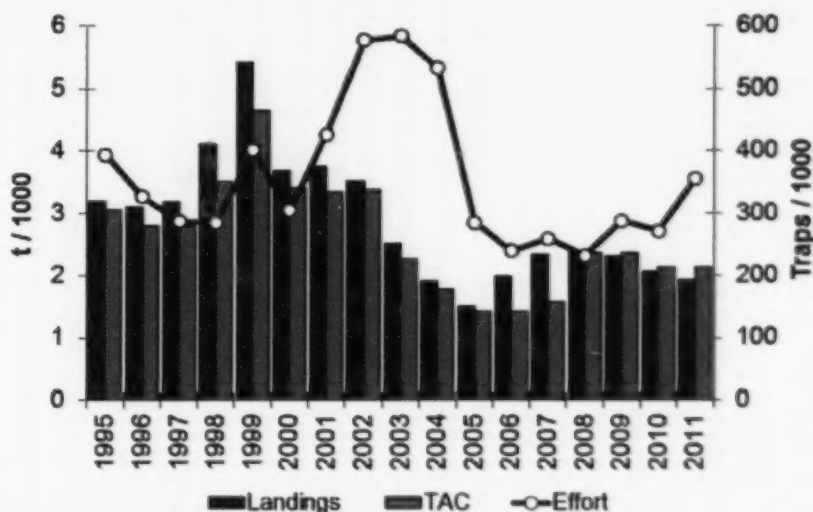


Figure 9: Trends in TAC, landings, and fishing effort in Div. 2J.

Commercial catch rate (CPUE) has oscillated over the time series (Fig. 10), initially decreasing from 1991-1995, and increasing to a peak in 1998. It declined steadily by 76% from 1998 to a record low level in 2004. It increased to a peak in 2008 and has since decreased by half, based on observer and logbook indices. The increase in VMS CPUE in 2011 was likely due to earlier fishing by large vessels, equipped with VMS, than by smaller vessels.

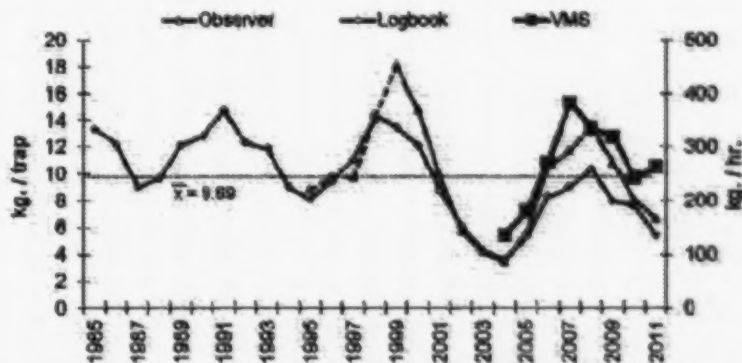


Figure 10: Trends in Div. 2J commercial CPUE. Horizontal line indicates the long-term average based on logbooks.

Biomass

The **exploitable biomass** has decreased in recent years. The post-season trawl survey exploitable biomass index decreased steadily by 92%, from 1998-2002 (Fig. 11). It increased from 2002 to peak in 2006 but remained below pre-2002 levels and has since decreased by half. The post-season trap survey index declined sharply from 2007-2009 and since increased to 2011. However, that index reflects only the Hawke Channel in the southern portion of the Division.

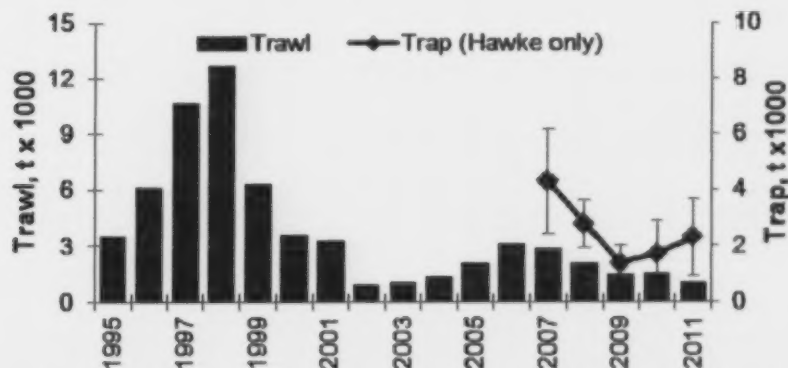


Figure 11: Trends in the Div. 2J exploitable biomass indices based on post season trawl and trap surveys. The trap survey is conducted only in the southern portion of the Division.

Recruitment

Recruitment has recently been in decline, as reflected by the decline in exploitable biomass between 2006 and 2009 while landings declined since 2008. It is expected to remain low in the short term. The post-season trawl survey pre-recruit index was exceptionally high in 2004, decreased sharply in 2005, and has since fluctuated without trend (Fig. 12). The post-season trap survey index, from the southern portion of the Division only (Hawke Channel), has changed little over its limited time series (Fig. 12).

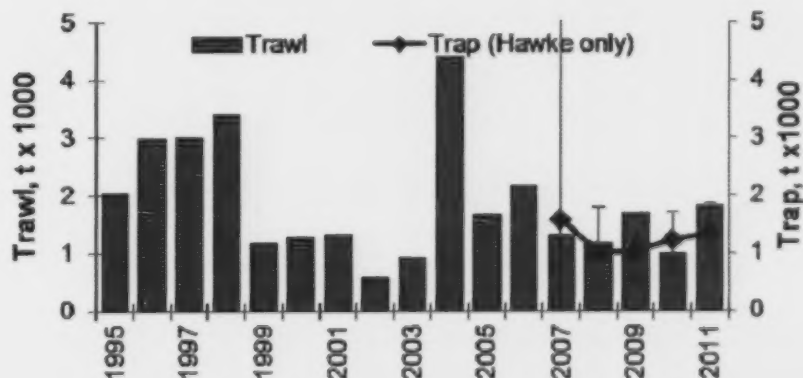


Figure 12: Trends in Div. 2J pre-recruit biomass indices from the post-season trawl survey and the CPS trap survey. The trap survey is conducted only in the southern portion of the division.

The ocean climate indices imply some possible improvement in recruitment in the near future (around 2012-2015), due to a relatively cold ocean climate regime 6 years earlier during 2006-

2009 (Fig. 13), that is inconsistent with the trawl survey indices (Fig. 12). However, long-term recruitment prospects are unfavourable due to a warming oceanographic regime. The overall trend is of a warming regime, with record warm conditions in 2010 and 2011.

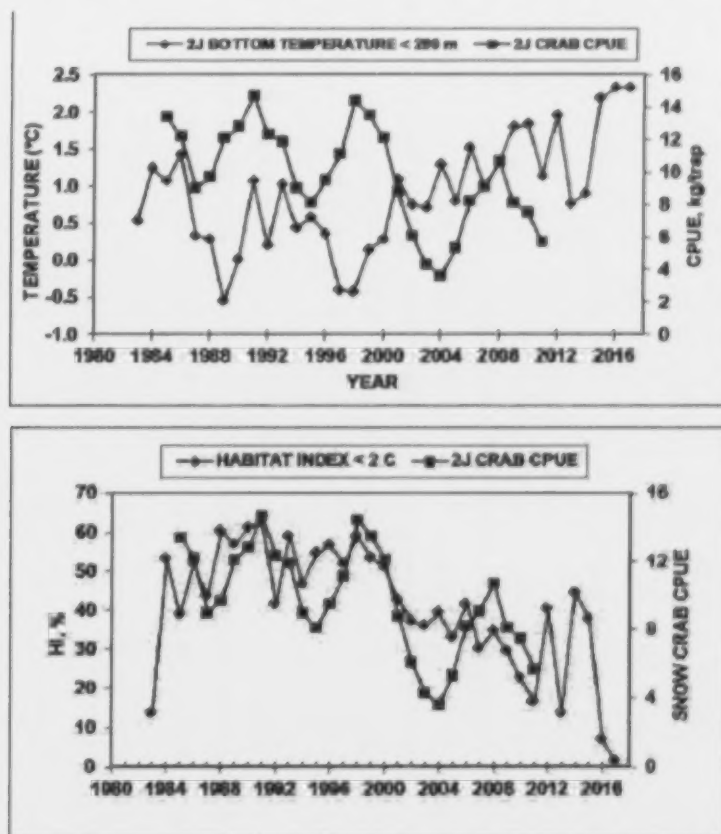


Figure 13: Relationship of Div. 2J CPUE with ocean climate indices 6 years earlier; bottom temperature above and habitat index below.

Mortality

The percentage of the total catch discarded (Fig. 14) increased from 2001 to a record high level in 2004. It then declined sharply to 2006, implying reduced wastage of under-sized and new-shelled pre-recruits in the fishery. It has since increased to 2011, but remains lower than during 2002-2005.

The **exploitation rate index** declined from 2003-2007 and then increased to 2010. However, it has changed little in the past three years (Fig. 14). The **pre-recruit fishing mortality rate index** declined sharply from 2003-2005, remained low in recent years, but increased to its highest level since 2004 in 2011.



Figure 14: Trends in the Div. 2J exploitation rate and pre-recruit fishing mortality rate indices and percentage of the catch discarded in the fishery.

Resource Status, Division 3K Offshore

Commercial Fishery

Landings first peaked in 1999 at 17,900 t (Fig. 15). They decreased to about 13,000 t in 2000-2004, due to a reduction in the TAC. They decreased sharply in 2005 when the TAC was not fully subscribed because the fishery was closed prematurely due to high levels of soft-shelled crabs in the catch. Landings more than doubled from 6,000 t in 2005 to peak at 12,600 t in 2009 but decreased by 35% to 8,200 t in 2011. The TAC was not achieved in the past 2 years. Effort decreased sharply in 2005 and changed little until it increased by 71% in 2009 before decreasing by 15% in 2010 and increasing marginally in 2011.



Figure 15: Trends in TAC, landings, and fishing effort in Div. 3K offshore.

Commercial CPUE (Fig. 16) indicates substantial deterioration of fishery performance in recent years. CPUE indices increased sharply from 2005 to record high levels in 2007 (VMS index) or

2008 (logbook and observer indices). All three indices agree that CPUE has declined sharply since 2008.

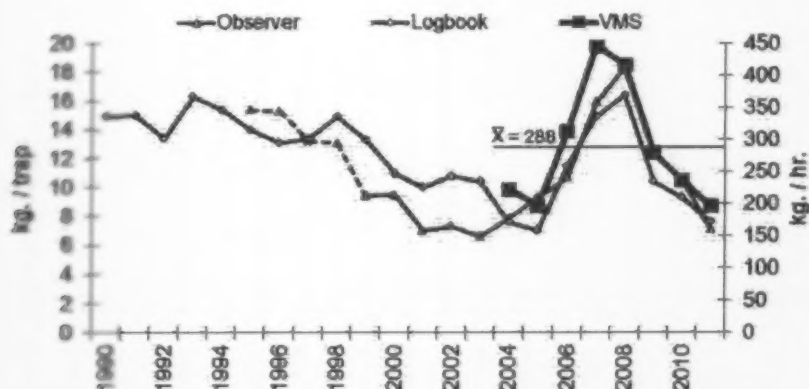


Figure 16: Trends in Div. 3K offshore commercial CPUE. Horizontal line indicates the VMS average. The observer index is based on at-sea sampling since 1999 (solid line) and catch estimates in earlier years (dashed line).

Biomass

The **exploitable biomass**, as indicated by the post-season trap and trawl survey indices, declined by more than half since 2008 (Fig. 17). The post-season trawl survey **exploitable biomass index** decreased from its highest level in the late 1990's to its lowest in 2003, before increasing to 2007. The post-season trap survey exploitable biomass index increased in 2006 (Fig. 17). Both indices remained high to 2008 and declined steadily, by about 60%, to 2011.

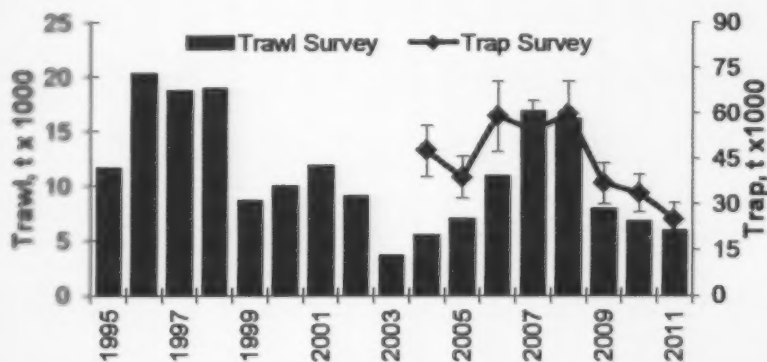


Figure 17: Trends in the Div. 3K offshore exploitable biomass indices based on post-season trawl and trap surveys.

Recruitment

Recruitment decreased in 2011 and is expected to decrease further in 2012. Prospects remain poor in the short term. Post-season pre-recruit biomass indices from both trap and trawl surveys have decreased by about 40% since 2008 (Fig. 18).

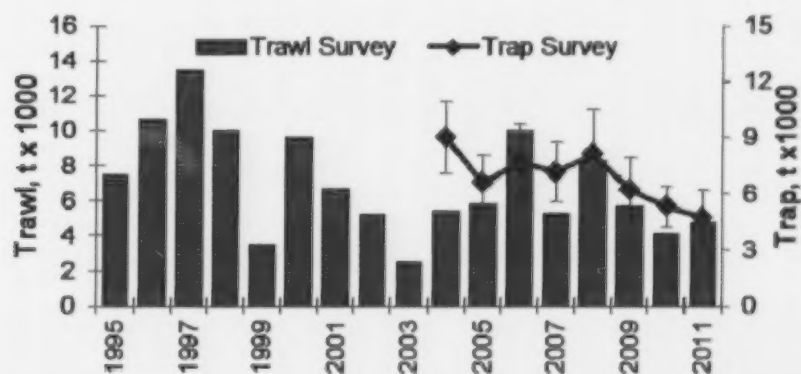


Figure 18: Trends in Div. 3K offshore pre-recruit biomass indices based on post-season trawl and trap surveys.

The recent decrease in recruitment was likely exacerbated by a high handling mortality on soft-shelled immediate pre-recruits in the fishery during recent years.

The ocean climate indices imply some possible improvement in recruitment in the near future (around 2012-2015), due to a relatively cold ocean climate regime 6 years earlier during 2006-2009 (Fig. 19), that is inconsistent with the survey indices (Fig. 18). However, long-term recruitment prospects are unfavourable, due to a warming oceanographic regime. The overall trend is of a warming regime, with record warm conditions in 2011 (Fig. 19). Data from CPS post-season small-meshed traps show no evidence of progression of small adolescent males through size frequency distributions.

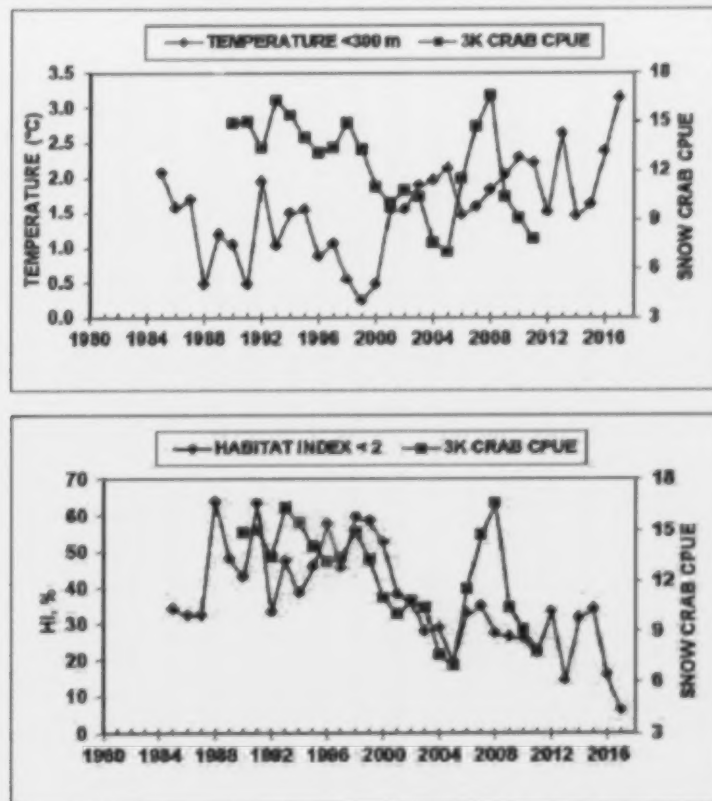


Figure 19: Relationship of offshore Div. 3K CPUE with ocean climate indices 6 years earlier; bottom temperature above and habitat index below.

Mortality

The percentage of the total catch discarded in the fishery (Fig. 20) declined markedly from 2004 to its lowest value in 2008. It has since increased to 2011, implying an increase in wastage of under-sized and soft-shelled pre-recruits in the fishery.

The trawl survey-based **exploitation rate index** declined sharply between 2006 and 2008 and has since increased back to the 2006 level. The **pre-recruit fishing mortality rate index** increased from 2007-2011 (Fig. 20)

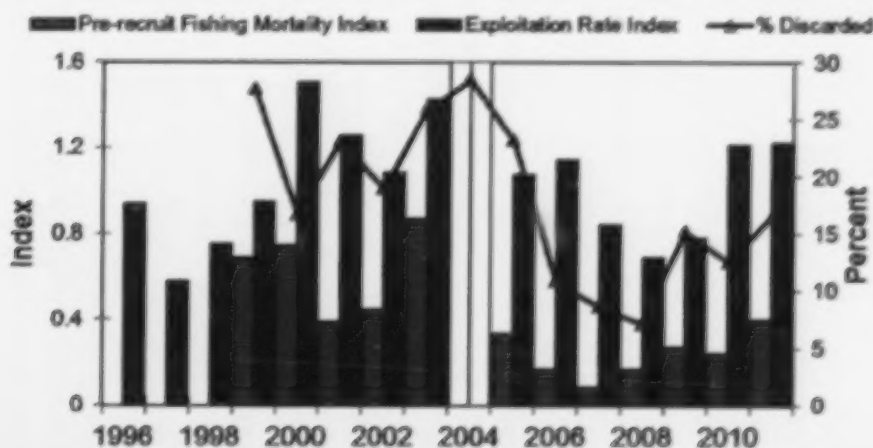


Figure 20: Trends in the Div. 3K offshore exploitation rate and pre-recruit fishing mortality rate indices and percentage of the catch discarded in the fishery. Anomalously high values for 2004 mortality indices are due to very low 2003 biomass indices.

Division 3K Inshore

Commercial Fishery

Landings (Fig. 21) first peaked in 1999 at 3,500 t and decreased sharply in 2000 due to a TAC reduction. They increased to 3,300 t in 2003, changed little in 2004, and decreased by 21% in 2005. They increased from 2,700 t in 2005 to 3,600 t in 2009, but decreased by 31% to 2,500 t in 2011. The TAC was not taken in 3 of the 5 management areas in 2011. **Effort** declined from 2004 to 2008 and has since increased by 64%.

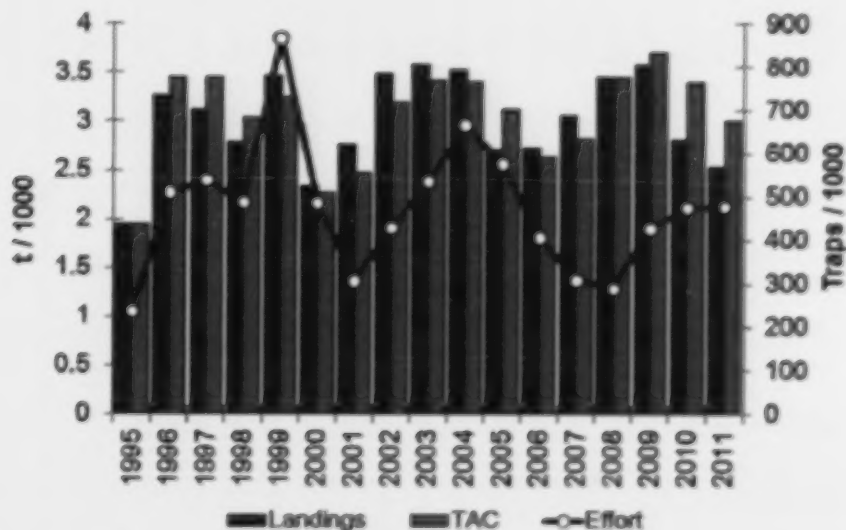


Figure 21: Trends in TAC, landings, and fishing effort in Div. 3K inshore

Commercial CPUE (Fig. 22) indicates substantial deterioration of fishery performance over the past three years. CPUE increased sharply from 2005 to a record high level in 2008, but has since declined by more than half.

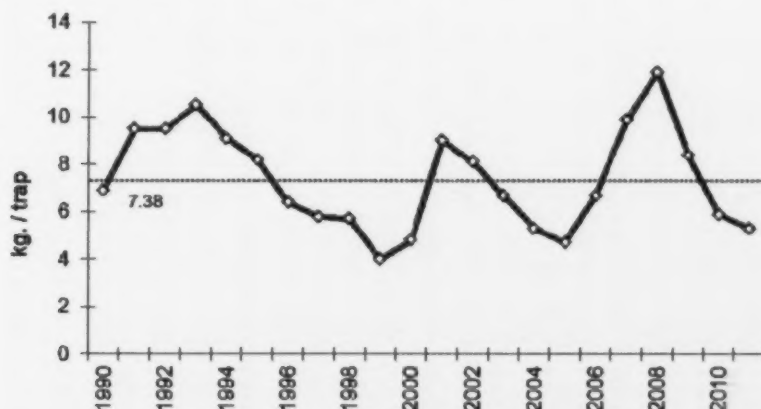


Fig. 22. Trend in Div. 3K inshore commercial CPUE. Dotted line represents the long-term average.

Biomass

The **exploitable biomass**, as indicated by the post-season trap survey index, decreased gradually between 2007 and 2010 and since changed little but there is considerable variability among management areas. (Fig. 23). Changes in fishery and survey performance in 2009 and 2011, within one particular management area (White Bay), affected trends in the overall biomass index.

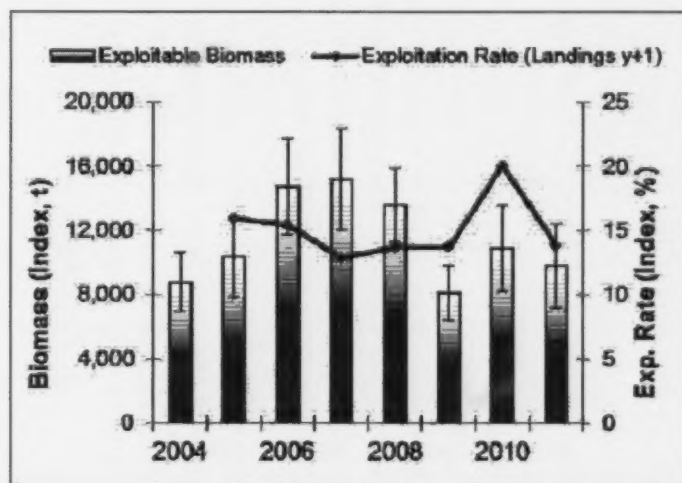


Figure 23: Exploitable biomass index based on the post-season trap survey in inshore Div. 3K.

Recruitment

While uncertain, **recruitment prospects** appear to have changed little and there is considerable variability among management areas. The CPS pre-recruit biomass index of undersized crabs (Fig. 24), has varied without trend throughout the time series.

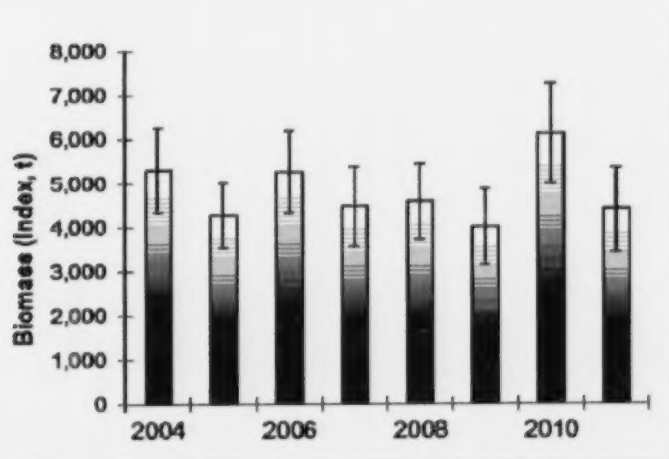


Figure 24: Pre-recruit biomass index of under-sized crabs from the post-season trap survey in inshore Div. 3K.

Mortality

The trap survey-based **exploitation rate index** increased sharply in 2010 and then returned to the 2007–2009 level in 2011 (Fig.23). Data are insufficient to estimate the **pre-recruit fishing mortality rate index**.

Resource Status, Division 3LNO Offshore

Commercial Fishery

Landings, mostly in Div. 3L, decreased from 24,500t in 2007 to 22,000t in 2009 but since increased to 26,000 t (Fig. 25). **Effort** increased slightly in 2011 following a 2008-2010 decrease.

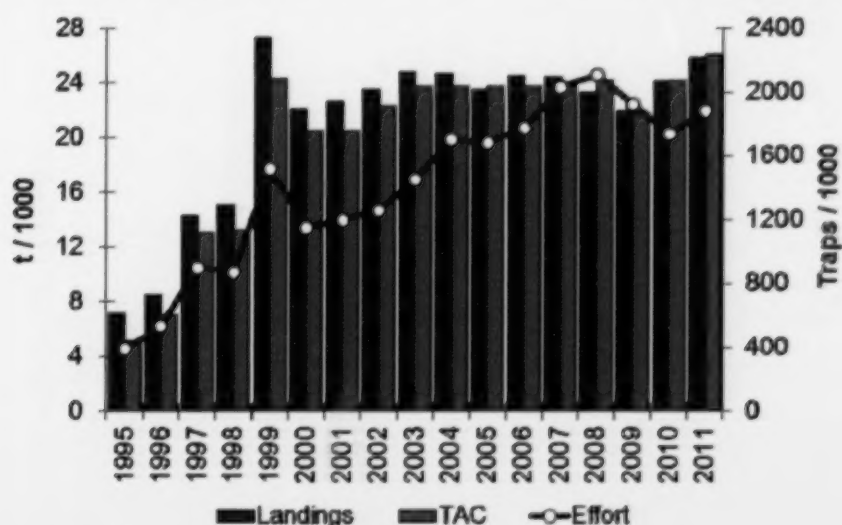


Figure 25: Trends in TAC, landings, and fishing effort in Div. 3LNO offshore.

Commercial CPUE (Fig. 26) indicates that fishery performance has recently improved. VMS-based CPUE declined to its lowest level in 2008, but has since increased to the long-term average.

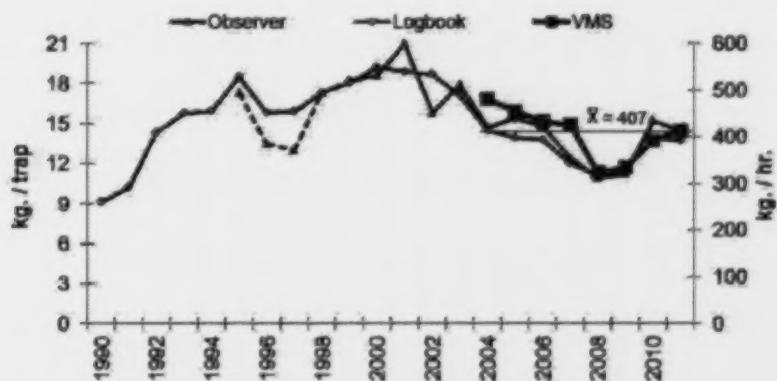


Figure 26: Trends in Div. 3LNO offshore commercial CPUE. Horizontal line indicates the average of the VMS index. The observer index is based on at-sea sampling since 1998 (solid line) and catch estimates in earlier years (dashed line).

Biomass

Both the trap and trawl survey exploitable biomass indices increased in 2009 (Fig. 27). However, the trawl survey index decreased by 34% since 2009 while the trap survey index increased by 21%. Opposing survey trends create uncertainty about the exploitable biomass.

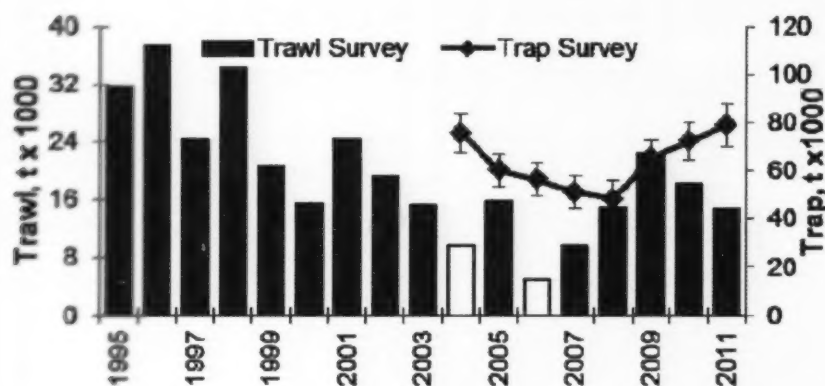


Figure 27: Trends in the Div. 3LNO offshore exploitable biomass indices based on post-season trawl and trap surveys; the trawl survey was incomplete in 2004 and 2006.

Recruitment

Recruitment has recently peaked and will likely decrease in the short term. The high level of pre-recruit biomass indices from both trap and trawl surveys during 2008-2010 (Fig. 28) reflects the prominence of a group of large adolescents in both in the trap and trawl survey size distributions in those years. The sharp decrease in the pre-recruit biomass index from both surveys in 2011 (Fig. 28) reflects the progression of that modal group to legal size. Most adolescents of this recruitment pulse have now recruited to the exploitable biomass as terminally-molted adults.

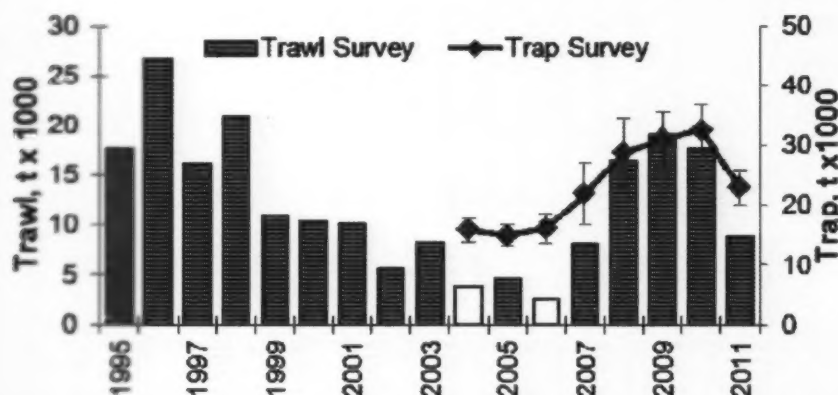


Figure 28: Trends in Div. 3LNO offshore pre-recruit biomass indices based on post-season trawl and trap surveys; the trawl survey was incomplete in 2004 and 2006.

A decline in recruitment in the short term is consistent with the expected negative effect of a very warm oceanographic regime during 2004-2006 on early survival and subsequent recruitment 8 years later during 2012-2014 (Fig. 29). The ocean climate indices imply some possible improvement in recruitment beyond the short term (in 4-6 years). However, long-term recruitment prospects are unfavourable due to a warming oceanographic regime. The overall trend is of a warming regime, with record warm conditions in 2011 (Fig. 29). Data from CPS

post-season small-meshed traps show no evidence of progression of small adolescent males through size frequency distributions in recent years.

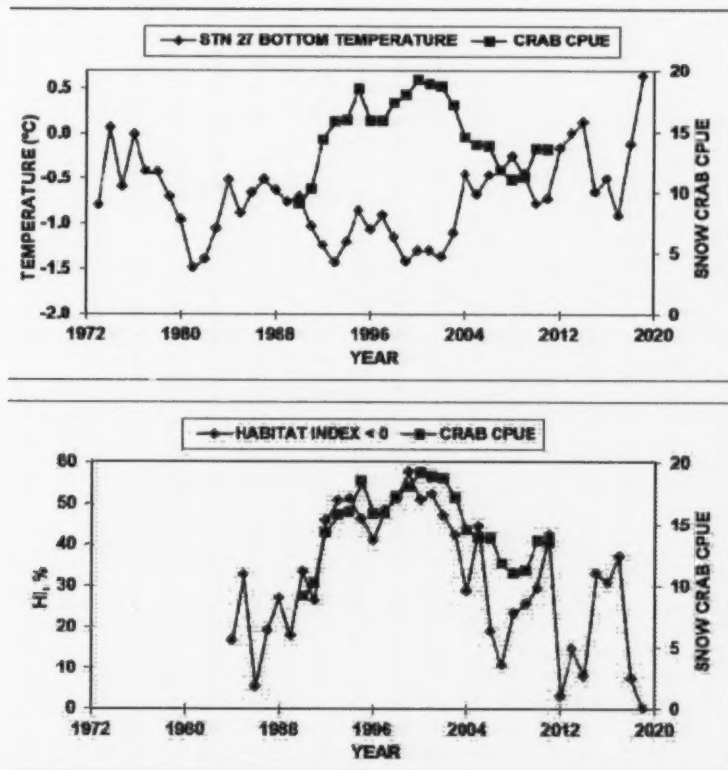


Figure 29: Relationship of Div. 3LNO CPUE with ocean climate indices 8 years earlier; bottom temperature above and habitat index below.

Mortality

The percentage of the total catch discarded in the fishery (Fig. 30) increased sharply in 2008 from a low level during 2004-2007. It has since declined, implying reduced wastage of pre-recruits, primarily sub-legal sized crabs in the fishery in recent years.

The **exploitation rate index** increased in 2011 following a sharp decrease from 2008-2010 while the **pre-recruit fishing mortality rate index** has remained near its lowest level during the past three years (Fig. 30)

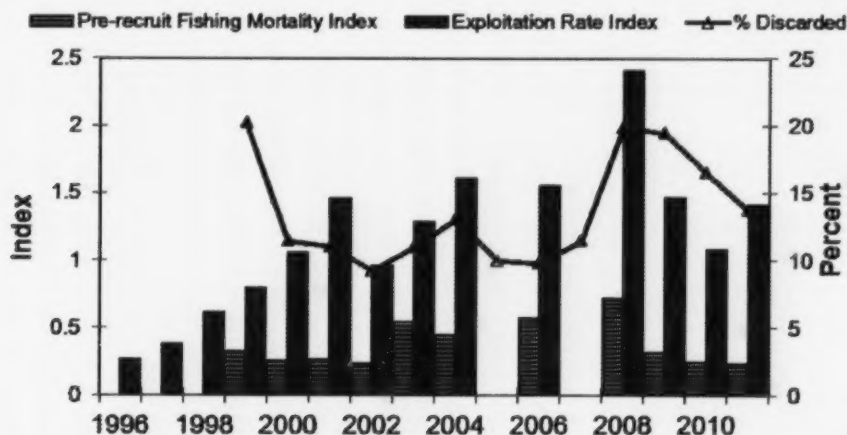


Figure 30: Trends in the Div. 3LNO offshore exploitation rate and pre-recruit fishing mortality rate indices and percentage of the catch discarded in the fishery. Mortality indices were not calculated for 2005 and 2007 because the survey was incomplete in 2004 and 2006.

Div. 3L Inshore Resource Status

Commercial Fishery

Landings peaked in 1996 at 7,900 t (Fig. 31). They declined to 4,700 t in 2000, increased to 6,800 t in 2003, and decreased slightly to 2005 due to changes in the TAC. They increased by 19% from 6,100 t in 2005 to 7,300 t in 2010 and decreased slightly to 7,100 t in 2011. **Effort** increased by 24% from 2008-2010 but decreased slightly in 2011.

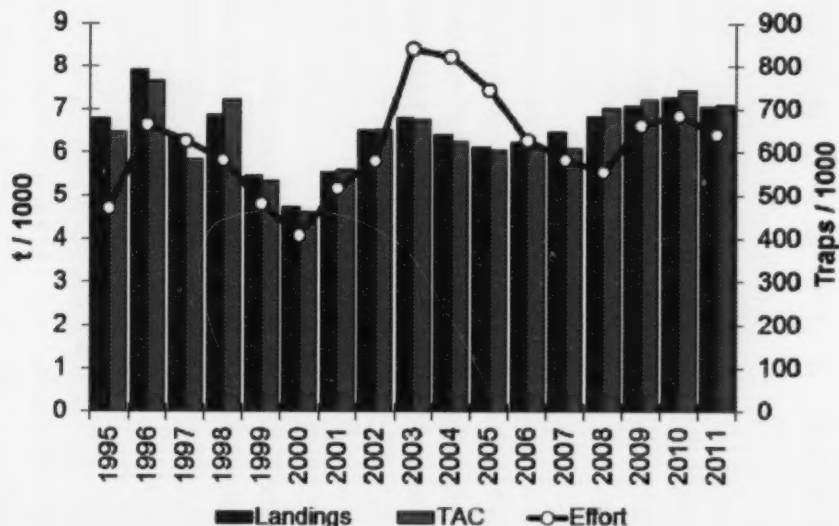


Figure 31: Trends in TAC, landings, and fishing effort in Div. 3L inshore.

CPUE increased from 2004-2008 and decreased in 2009 (Fig. 32). It has remained at the long-term average for the past three years.

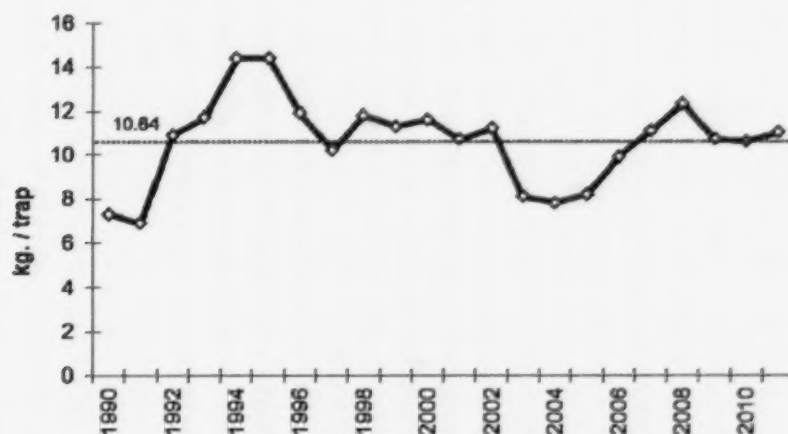


Figure 32. Trends in Div. 3L inshore commercial CPUE. Dotted line represents the long-term average.

Biomass

The post-season trap survey index suggests that the **exploitable biomass** has changed little over the past eight years (Fig. 33).

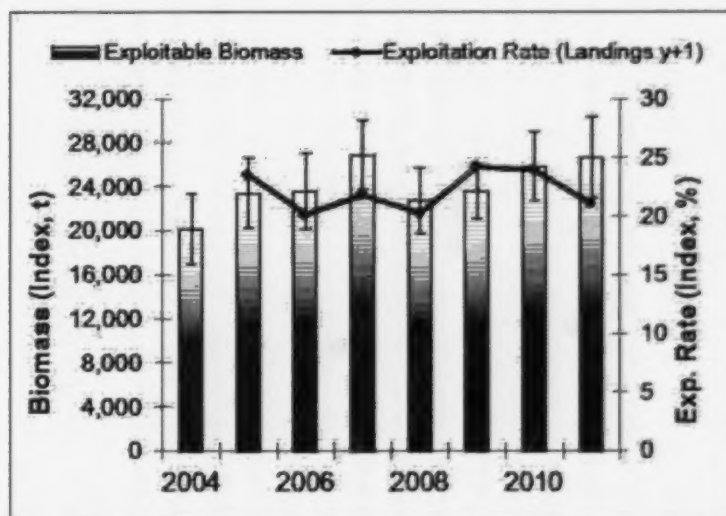


Figure 33: Exploitable biomass and exploitation rate indices based on the post-season trap survey in inshore Div. 3L.

Recruitment

Overall, **recruitment** prospects have recently improved. The post-season trap survey pre-recruit index increased from 2008-2010 and was unchanged in 2011 (Fig. 34). However, there is considerable variability among management areas.

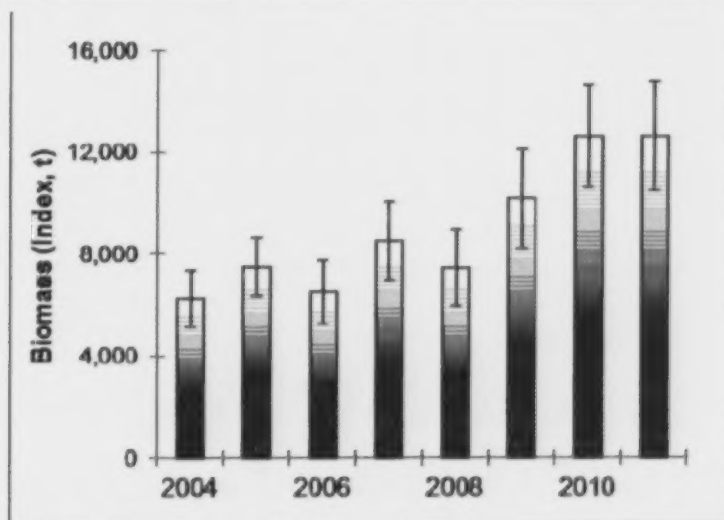


Figure 34: Pre-recruit biomass index of under-sized crabs from the post-season trap survey in inshore Div. 3L.

Mortality

The trap survey-based **exploitation rate index** decreased slightly in 2011 (Fig. 33). Data are insufficient to estimate a **pre-recruit fishing mortality rate index**.

Resource Status, Subdivision 3Ps Offshore

Commercial Fishery

Landings varied little, at 4,300–4,400 t during 1999–2002, before declining by about half to 2006. They almost doubled from 2,300 t in 2006 to 4,300 t in 2011 (Fig. 35). Meanwhile **effort** decreased from 2006 to 2008 and since increased by 56%.

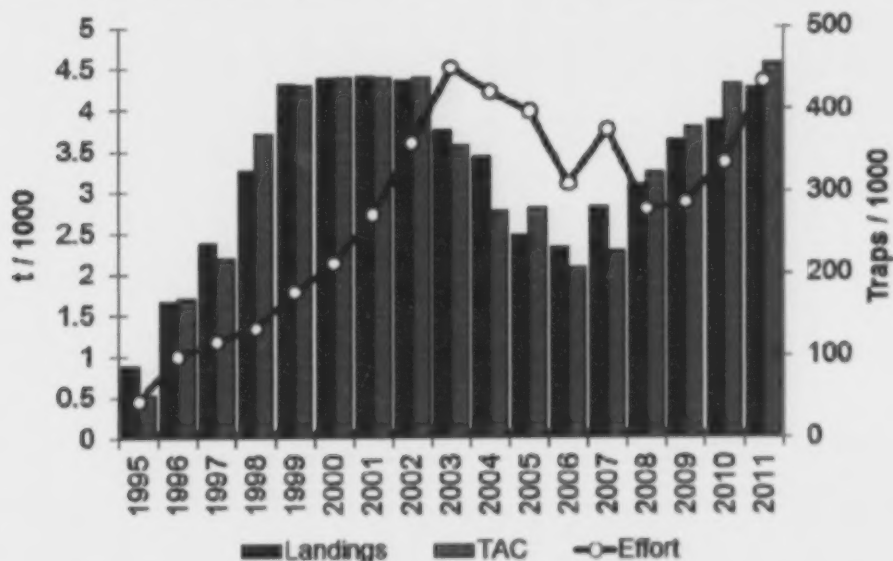


Figure 35: Trends in TAC, landings, and fishing effort in Subdiv. 3Ps offshore

CPUE declined substantially from 1999-2005. It increased from 2005-2009 and has since declined slightly (Fig. 36).

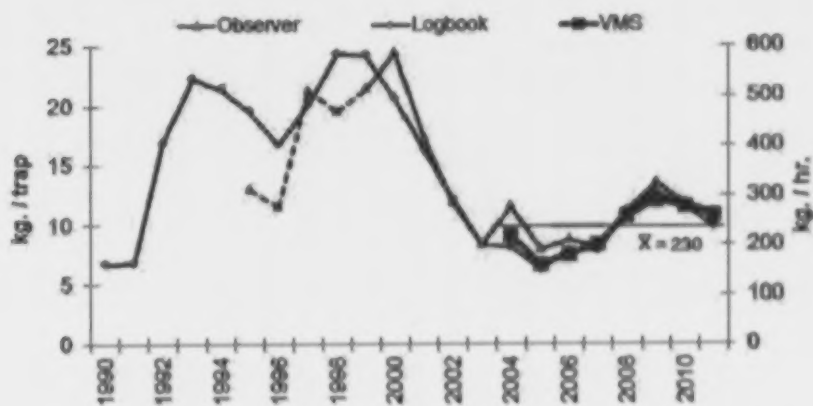


Figure 36: Trends in Subdiv. 3Ps offshore commercial CPUE. Horizontal line indicates the average of the VMS index. The observer index is based on at-sea sampling since 1999 (solid line) and catch estimates in earlier years (dashed line).

Biomass

The **exploitable biomass**, as indicated by both the spring trawl survey and the post-season trap survey indices, increased steadily from 2006-2009 and has since declined sharply to 2011 (Fig. 37).

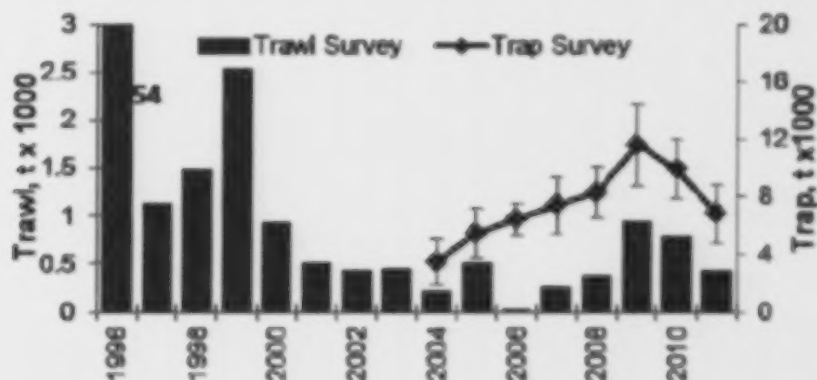


Figure 37: Trends in the Subdiv. 3Ps offshore exploitable biomass indices from the pre-season trawl survey and the post-season trap survey; the trawl survey was incomplete in 2006.

Recruitment

Recruitment has recently declined and is expected to decline further in the short term. Post-season pre-recruit biomass indices from both trap and trawl surveys increased in 2009 and have since declined sharply to 2011 (Fig. 38).

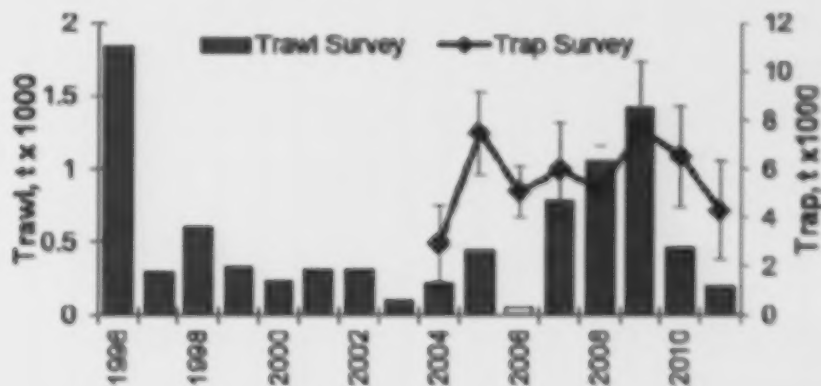


Figure 38: Trends in the pre-recruit biomass indices from the pre-season trawl survey and the post-season trap survey in Subdiv. 3Ps offshore; the trawl survey was incomplete in 2006.

The ocean climate indices imply some possible improvement in recruitment in the near future (around 2014-2015), due to a relatively cold ocean climate regime 7 years earlier during 2007-2008 (Fig. 39), that is inconsistent with the survey indices (Fig. 38). However, long-term recruitment prospects are unfavourable due to a warming oceanographic regime. The overall trend is of a warming regime, with very warm conditions in 2011 (Fig. 39). Data from CPS post-season small-meshed traps show no evidence of progression of small adolescent males through size frequency distributions in recent years.

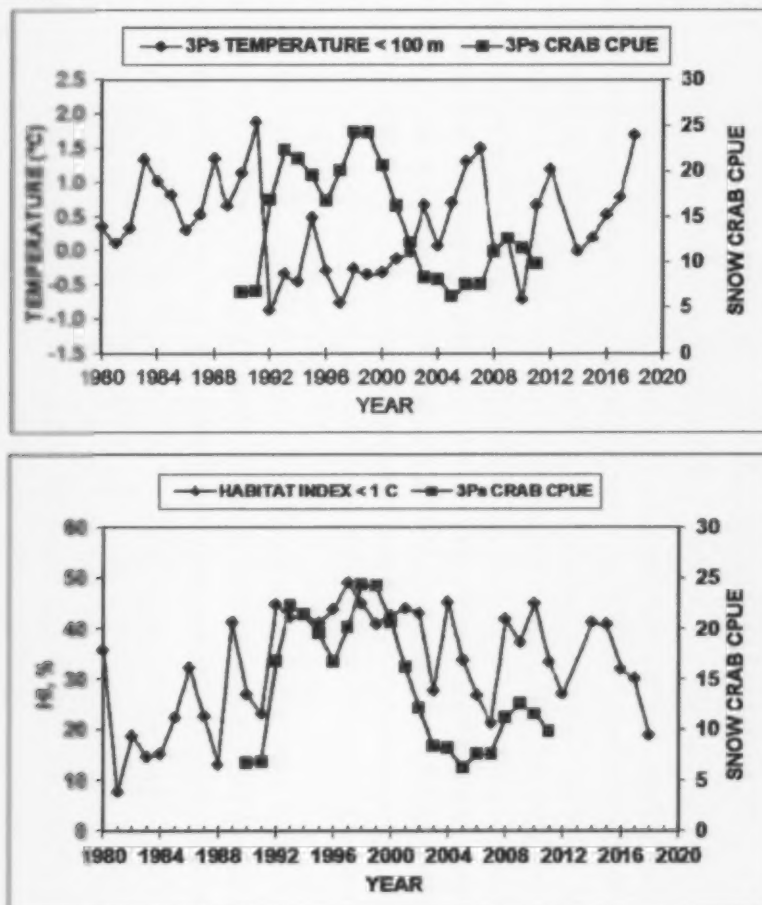


Figure 39: Relationship of offshore Subdiv. 3Ps CPUE with ocean climate indices 7 years earlier; bottom temperature above and habitat index below. Note: the ocean climate indices are missing for 2013 due to an incomplete 2006 survey.

Mortality

The percentage of the total catch discarded in the fishery (Fig. 40) peaked at about 45% in 2005, declined by half to 2008 and has since changed little, implying a reduction in wastage of pre-recruits in recent years. The percent discarded in Subdiv. 3Ps is generally higher than in other areas as it includes a larger component of under-sized crabs, an unknown but high portion of which is comprised of small adults that will never recruit to the fishery.

Exploitation and pre-recruit fishing mortality rates, as indicated by spring trawl survey indices, decreased from 2007-2009 but increased sharply to 2011 to their highest values since 2007 and 2003 respectively (Fig. 40).

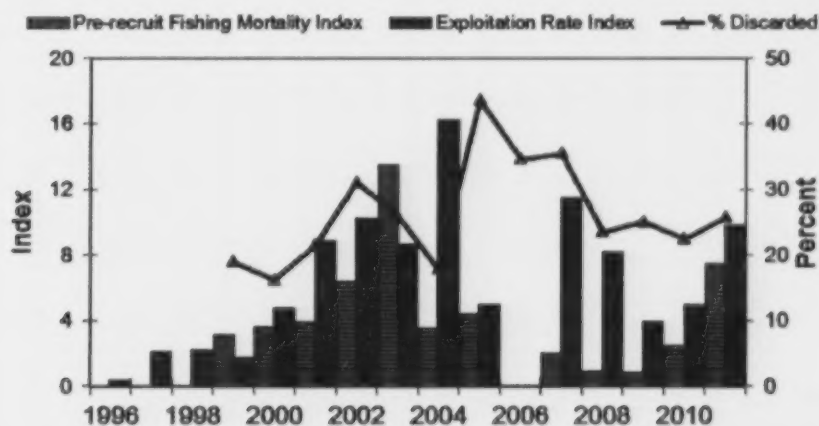


Figure 40: Trends in the Subdiv. 3Ps offshore exploitation rate and pre-recruit fishing mortality indices and percentage of the catch discarded in the fishery. Mortality indices were not calculated for 2006 because the survey was incomplete in that year.

Subdiv. 3Ps Inshore

Commercial Fishery

Landings varied little, at 3,300-3,600 t during 1998-2002, before declining by a factor of 5 to 2005 (Fig. 41). They then more than tripled from 700 t in 2005 to 2,500 t in 2011. Meanwhile effort declined from 2005-2010 and increased by 22% in 2011.

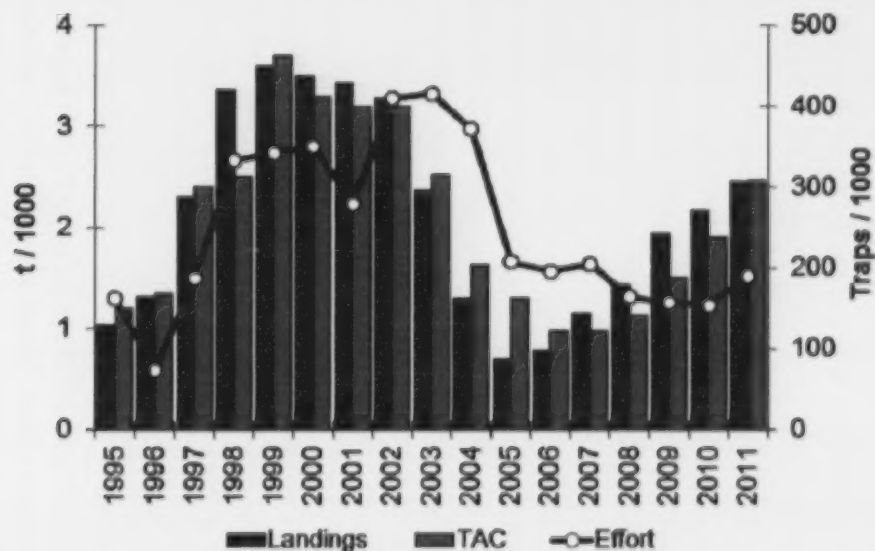


Figure 41: Trends in TAC, landings, and fishing effort in Subdiv. 3Ps inshore

CPUE declined from 2001-2005, increased steadily from 2005 to its highest level since 1996 in 2010 and decreased marginally in 2011. (Fig. 42).

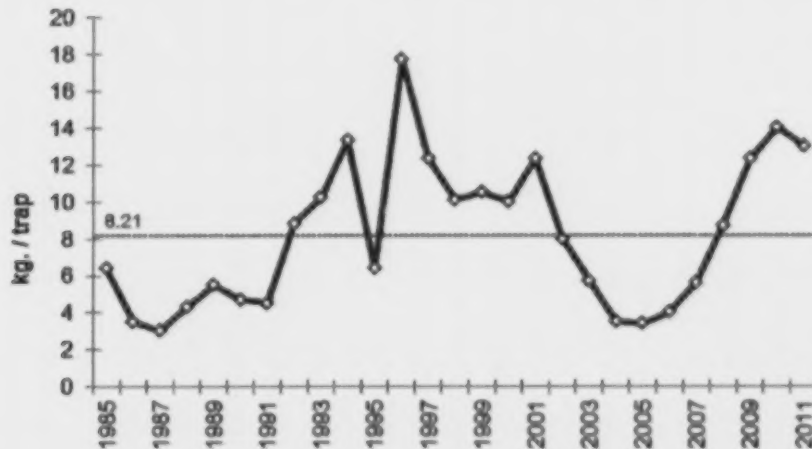


Figure 42: Trends in Subdiv. 3Ps inshore commercial CPUE. Dotted line represents the long-term average.

Biomass

The **exploitable biomass**, as indicated by the post-season trap survey index, increased substantially between 2006 and 2010 and decreased in 2011 (Fig. 43).

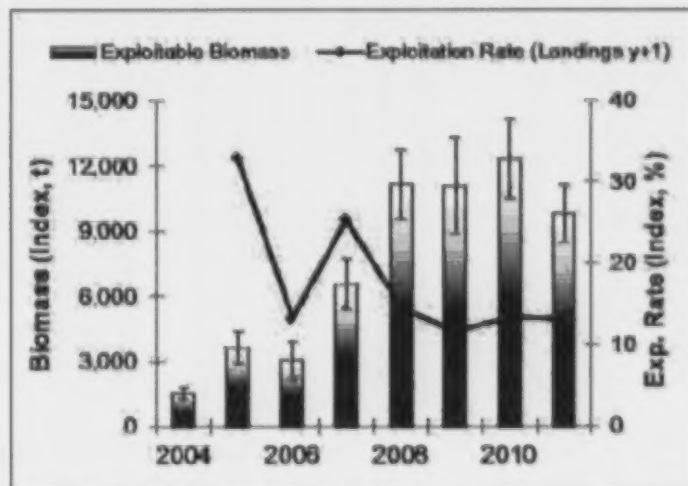


Figure 43: Exploitable biomass and exploitation rate indices based on the post-season trap survey in inshore Subdiv. 3Ps.

Recruitment

Recruitment decreased in 2011 and is expected to decrease further in the short term. The trap survey pre-recruit biomass index increased in 2007 and has since declined back to the pre-2007 level (Fig. 44). The pre-recruit biomass index for this subdivision includes a high proportion of small adults that will never recruit to the fishery.

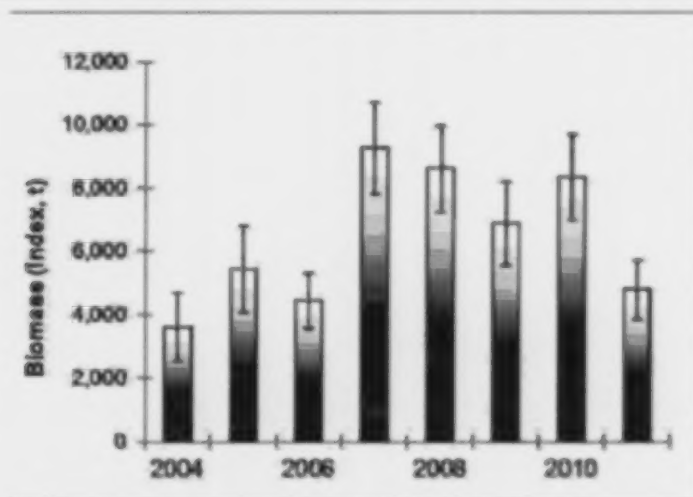


Figure 44: Pre-recruit biomass index of under-sized crabs from the post-season trap survey in inshore Subdiv. 3Ps.

Mortality

The post-season trap survey-based exploitation rate index changed little during 2008-2011. Data are insufficient to estimate a pre-recruit fishing mortality rate index. (Fig. 43).

Resource Status, Division 4R Offshore

Commercial Fishery

Landings declined substantially from 580 t in 2004 to 80 t in 2006 before more than doubling in 2007 (Fig. 45). They declined by 83% from 190 t in 2007 to a historical low of 30 t in 2010, but increased to 150 t in 2011. **Effort** increased by a factor of four in 2011 following the historical low in 2010. The TAC has not been taken since 2002.

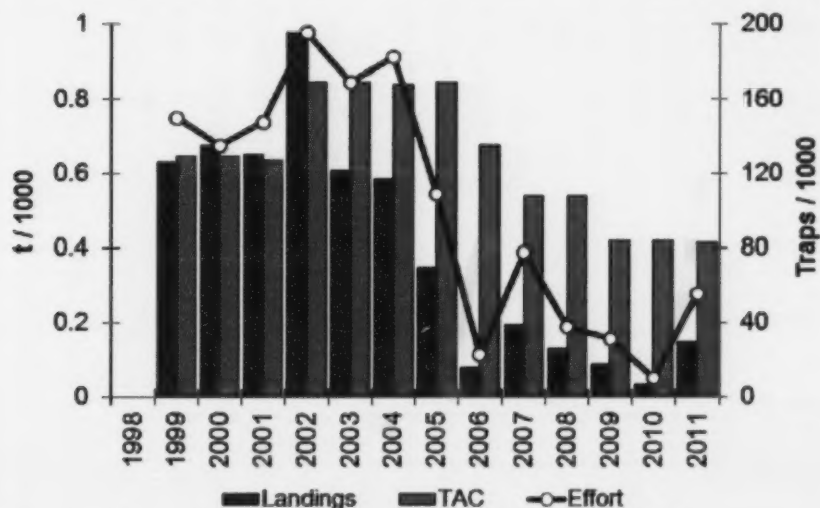


Figure 45: Trends in TAC, landings, and fishing effort in Div. 4R offshore.

CPUE declined from 2004 to a historical low in 2009, increased sharply in 2010, and fell to the 2009 level again in 2011. (Fig. 46). However, the 2010 increase was associated with a record low level of both landings and effort. CPUE has consistently been low relative to other divisions.

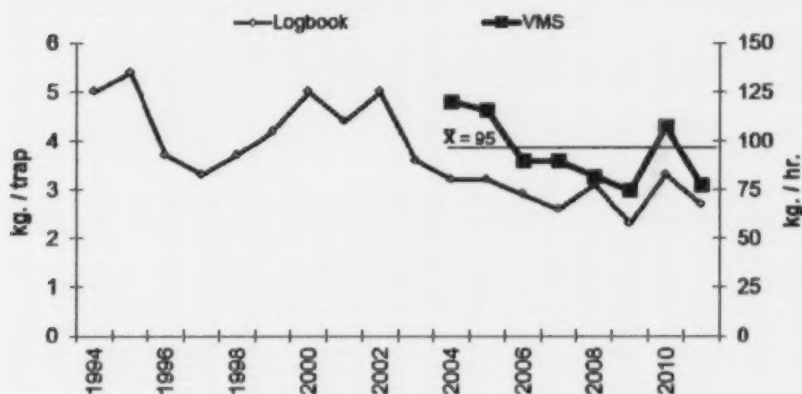


Figure 46: Trends in Div. 4R offshore commercial CPUE. Horizontal line indicates the average of the VMS index.

Biomass

The **exploitable biomass** remains low. The indices from both the post-season trap and trawl surveys increased to their highest values in 2011 (Fig. 47). However, survey catches are sporadic each year, resulting in very broad confidence intervals, particularly in 2011, introducing high uncertainty in interpreting annual changes.

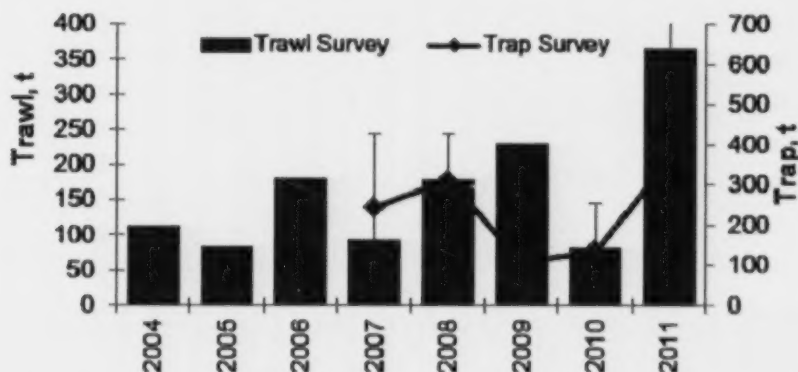


Figure 47: Trends in the Div. 4R offshore exploitable biomass indices from the post-season trawl and trap surveys.

Recruitment

Recruitment has been low in recent years and prospects are uncertain. The pre-recruit biomass indices from both surveys has changed little over the series (Fig. 48). Annual values are associated with broad confidence intervals due to sporadic survey catches.

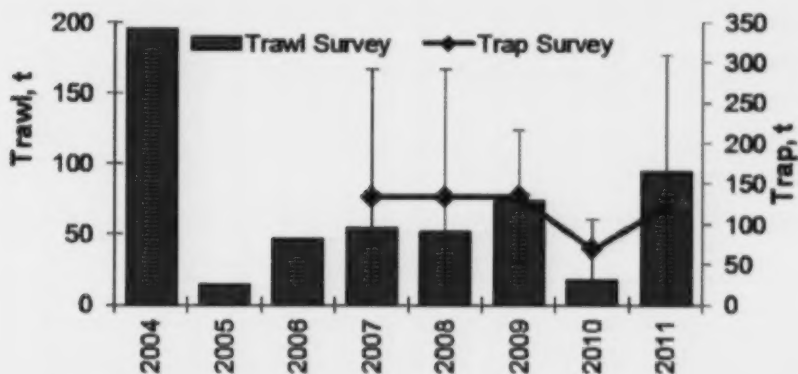


Figure 48: Trends in the pre-recruit biomass indices from the pre-season trawl survey and the post-season trap survey in Div. 4R offshore.

Mortality

Data are insufficient to calculate **exploitation rate** and **pre-recruit fishing mortality rate** indices.

Div. 4R Inshore Resource Status

Commercial Fishery

Landings declined sharply by 80 % from 950 t in 2003 to a historical low of 190 t in 2010 and increased to 450 t in 2011 (Fig. 49). **Effort** declined by 95% from 2004 to 2010 and doubled in 2011. The TAC has not been taken since 2003.

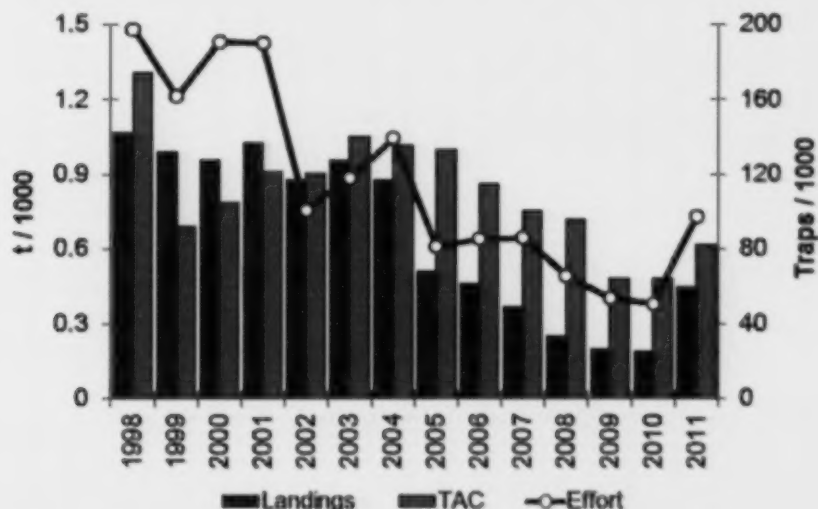


Figure 49: Trends in TAC, landings, and fishing effort in Div. 4R inshore.

CPUE declined from 2002-2007 and has since varied without trend below the long-term average (Fig. 50).



Figure 50: Trends in Div. 4R inshore commercial CPUE. Dotted line is the long-term average .

Biomass

The post-season trap survey **exploitable biomass** index changed little from 2005-2009 but has increased greatly in the past two years (Fig. 51).

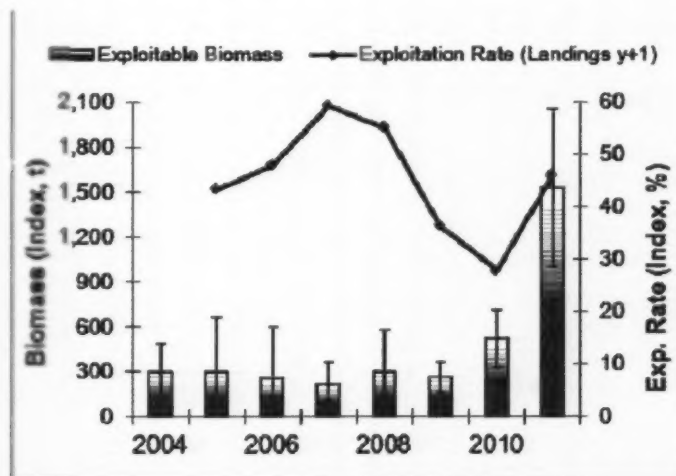


Figure 51. Exploitable biomass and exploitation rate indices based on the post-season trap survey in inshore Div. 4R.

Recruitment

Recruitment has recently increased and short-term prospects remain promising in most management areas. The post-season trap survey pre-recruit biomass index increased substantially in 2009 and has since remained above the pre-2009 level (Fig. 52).

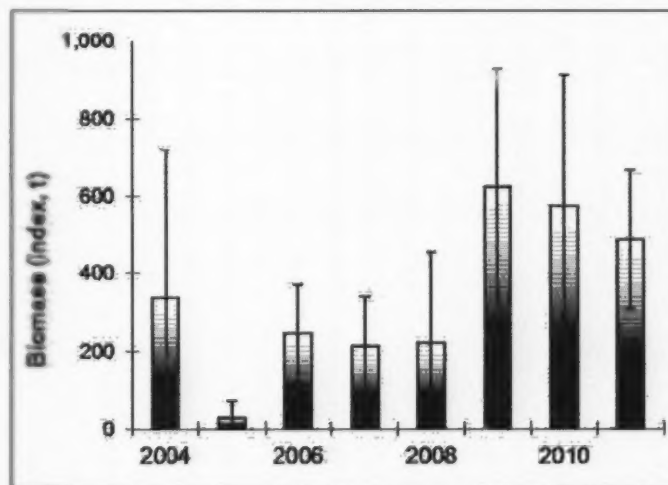


Figure 52. Trends in the pre-recruit biomass index from the post-season trap survey in inshore Div. 4R.

Mortality

The post-season trap survey-based **exploitation rate** index decreased from 2007-2010 but increased sharply in 2011 (Fig. 51). Data are insufficient to estimate a **pre-recruit fishing mortality rate index**.

Sources of Uncertainty

There are several sources of uncertainty that affect the interpretation of trends in biomass, recruitment and mortality that represent the basis for this assessment: Uncertainties that affect post-season survey indices are more important than those that affect indices based on fishery performance.

Biomass and Recruitment Indices

Survey Indices

Interpretation of trends in exploitable and pre-recruit biomass indices from surveys is highly uncertain if the survey was incomplete (ie. Div. 3LNO in 2004 and 2006 and Subdiv. 3Ps in 2006). The multispecies trawl surveys commonly fail to sample inshore areas so they are used only for offshore areas. This introduces considerable uncertainty for all inshore areas because biomass and recruitment indices are available from only one source, the CPS trap survey. In the present assessment an incomplete DFO trap survey in 2009 and 2011 introduced considerable uncertainty in interpreting trends for inshore Div. 3K.

Exploitable and pre-recruit biomass indices are also affected by annual variation in the catchability of crabs by the multispecies survey trawl and indices are typically associated with broad confidence intervals. This introduces uncertainty in interpreting annual changes in the exploitable biomass and predictions of changes in future recruitment. Trawl efficiency is directly related to crab size, so it is not possible to evaluate long term recruitment prospects based on the abundance index of smallest crabs. Indices from the spring trawl survey in Subdivision 3Ps carry higher uncertainty than do those from the fall surveys because the effects of the most recent fishery are not accounted for. Furthermore spring (pre-season) surveys are considered to be less reliable than summer and fall (post-season) surveys because some population components are relatively poorly sampled during spring when mating and molting take place. The exploitable biomass index from the summer Div. 4R survey is considered unreliable due to sporadic survey catches each year, associated with low biomass in that division. Uncertainty is especially high in interpreting recruitment prospects based on the pre-recruit biomass index from this survey because molt status is not determined (chelae are not measured). Therefore the pre-recruit biomass index includes an unknown portion of under-sized adults (terminally molted) that will never recruit to the fishery.

Exploitable and pre-recruit biomass indices from trap surveys are also affected by annual variation in catchability of crabs. Both DFO and collaborative post season trap surveys showed anomalously low biomass indices in inshore Div. 3K in 2009, due to reduced catchability, that resulted in high uncertainty regarding recent trends. There is also uncertainty in interpreting trends in biomass indices from the CPS survey because there is limited spatial coverage, especially in Div. 2J and Div. 3NO. Also, catch rates in this survey may be affected by adverse weather and other factors that affect soak time and trap efficiency. In the present assessment changes in fishery and survey performance in 2009 and 2011, within one particular management area (White Bay), affected trends in the overall biomass index. As with the Div. 4R

trawl survey uncertainty is especially high in interpreting recruitment prospects based on the pre-recruit biomass index from this survey because molt status is not determined. This is of greatest concern in Subdiv. 3Ps where a high proportion of males terminally molt below the legal size limit. There is uncertainty in using shell condition as a proxy indicator of molt status (adult versus adolescent) because of great variation in expertise among observers sampling during these surveys and subjectivity in assignment of shell stages.

Small-meshed traps are included in sampling by the CPS trap survey on some stations in most areas to provide an index of future recruitment based on catch rates of sub-legal sized adolescents. However there is uncertainty associated with very limited spatial coverage by small-meshed traps and high variability in trap catchability. Small adolescents may be particularly susceptible to trap catchability effects due to competition with larger and adult males.

Fishery Indices

Completion and timely return of logbooks is mandatory in this fishery. The reliability of the logbook data is suspect with respect to effort (ie. under-reporting) and areas fished. This is especially true of Div. 3LNO offshore, where logbook data are known to be unreliable due to inaccurate reporting. This introduces a strong bias in logbook CPUE as an index of exploitable biomass in some areas. However logbook data provide the best index in most inshore areas because VMS data are not available and observer coverage is commonly insufficient. There is uncertainty in interpreting trends from VMS-based CPUE in Div. 2H and Div. 2J because of incomplete coverage of the offshore fishery in those areas. There is further uncertainty regarding the reliability of logbook data in some areas (eg. Div. 2H and inshore Div. 4R) because of low levels of returns.

There is uncertainty regarding the effects of changes in some fishing practices (e.g. location, seasonality, soak time, trap mesh size, high-grading and bait efficiency) on commercial catch rates (CPUE) and their interpretation as indicators of trends in exploitable biomass. Some of these changes (eg. in mesh size and soak time) also affect catch rates of undersized crabs and so can compromise the utility of catch rate of undersized crabs as an index of future recruitment.

There are concerns regarding the utility of the observer data from at-sea sampling during the fishery due to low and spatiotemporally inconsistent coverage, especially in Div. 2H and 4R and all inshore areas. These concerns introduce a strong bias in interpreting trends in catch rates at broad spatial scales; in most divisions observer data are only useful for some inshore CMAs. Observer-based indices are also biased by inconsistent sampling methods and levels resulting from changing priorities. There are also concerns relating to variability in experience of observers in subjectively assigning shell stages. This introduces uncertainty in inferring recent recruitment trends and prospects based on catch rates of new-shelled crabs.

Long-Term Recruitment indices

Recruitment prospects for 6-8 future years are inferred from lagged relationships between fishery and survey exploitable biomass indices. These relationships are convincing because they are consistent among four offshore areas that show differing biomass oscillations at differing lags that are biologically meaningful. However, there is uncertainty regarding the reliability of these relationships as recruitment predictors. There is high uncertainty with respect to the sensitivity of these relationships in predicting response to slight changes in the ocean climate regime. For example, bottom temperature and habitat indices imply that that biomass may increase in the very near future in the northern areas (Div. 2J and 3K), but fishery and

survey catch rates show no indication of any such imminent increase in recruitment. There is also uncertainty in the longer term regarding trends in the ocean climate. A trend of recent warming is clearer in the northern areas (Div. 2J and 3K) than in the southern areas (Div. 3LNO and Subdiv. 3Ps). Continued long-term warming in all areas is inferred from low-frequency multi-decadal oscillations in the ocean climate of the entire Atlantic Ocean that, in recent years, are related to changes observed on the NL shelf (Colbourne et al. 2012). However, there is uncertainty regarding whether such long-term oscillations will persist as they have in the past. There is also concern that the biomass indices, based on the exploitable biomass do not account for possible effects of the fishery. Of particular concern is the potential effect of future changes in the fishery on these associations. Relationships have been developed only for offshore areas, for which extensive time series of biomass indices and ocean climate indices are available. Accordingly, there is uncertainty regarding their applicability to inshore areas.

Mortality Indices

Indices of fishery-induced mortality are subject to uncertainties associated with both survey and fishery data. Mortality indices are not estimated for years when the associated survey biomass index was not available or reliable. Trawl-based indices are not available for inshore areas. An exploitation rate index is estimated for inshore areas based on the post-season trap survey biomass index. However, this index may be biased by annual changes in the distribution of crabs or fishing effort inside versus outside the limited survey areas. The pre-recruit fishing mortality and discard indices are not estimated for inshore areas due to insufficient observer data.

Low and spatiotemporally variable observer coverage introduces high uncertainty in interpreting the effects of the fishery on pre-recruit mortality. There is particular concern that a low level of compliance by harvesters in accommodating observers may introduce bias in estimates of soft-shelled crab prevalence. This concern is especially relevant to areas of high soft-shell crab prevalence in recent years (ie. Div. 3K) and it introduces high uncertainty regarding the level of fishery-induced mortality on soft-shelled immediate pre-recruits. Ultimately this leads to uncertainty concerning the efficacy of the soft-shelled protocol in minimizing this source of mortality.

ADDITIONAL STAKEHOLDER PERSPECTIVES

2J

While catch rates and landings decreased overall in 2011, harvesters fishing early experienced good catch rates and had no problems catching their individual quotas. There is some uncertainty among harvesters however on the status of the resource. Harvesters are also concerned over the abundance of seals and groundfish and the effect that they are having on crab stocks.

3K

Catch rates have declined since 2008 in the offshore, noting however that 2008 produced the highest catch rates throughout the 21 year time series. Harvesters fishing early in the season in 2011 experienced excellent catch rates and had no trouble landing their individual quotas while those fishing later experienced lower catch rates. Harvesters have serious concerns over the increasing abundance of seals and groundfish and believe that they are having a negative impact on crab stocks. Harvesters are also concerned about the effects of shrimp trawling and

would like to see more work done to determine if indeed trawling is negatively affecting crab abundance. Catch rates declined in most inshore areas in 2011 with the exception of White Bay. Soft-shelled crab also posed problems in some areas and, as a result, not all areas reached their quotas. Harvesters are encouraged however by the abundance of soft shell crab in 2011 and are expecting those to recruit to the fishery in 2012. Harvesters are also encouraged by the positive results of the post-season trap survey and are expecting an improvement in fishery performance in 2012.

Divisions 3L

Inshore

Inshore harvesters are encouraged by the recruitment indicators that the stock is strong with large numbers of undersized animals observed and very low incidence of soft shelled animals. Harvesters feel that voluntary initiatives such as the Bonus Program, buffer zones, exclusion zones, escape mechanisms and bio-degradable twine that have been implemented in 3L have contributed to the overall health of the stock.

Offshore

In the offshore, the CPUE has been relatively stable in recent years. In 2011 harvesters felt the stock remained very strong with no significant occurrence of soft-shelled crabs. Harvesters also noted a significant improvement in recruitment of undersized animals in 2011.

3Ps

Landings increased in 2011 compared to 2010, while the CPUE has shown a decline. Harvesters attribute some of the decline to the length of the season, with the stock in good shape. Harvesters also noted that due to the distance from land as well as the cost of fuel and bait, not all of the offshore TAC was taken.

Harvesters expressed concern with the results of the spring pre-season trawl survey in 2011 and concluded that there was a continued decline in recruitment compared to 2010. The post-season trap survey recruitment index has declined causing some concern for harvesters. Fairly good catch rates in the 2011 commercial fishery has led harvesters to remain optimistic about the future of the fishery.

4R

Effort and landings increased in the offshore in 2012 while catch rates decreased. Increased market conditions resulted in more vessels participating with some vessels fishing in traditionally less productive areas which negatively impacted CPUE. Harvesters are encouraged by the increased abundance of soft-shelled crab observed in 2011 and believe that this crab will contribute to the 2012 fishery. Harvesters are also encouraged by the increase in the exploitable biomass index from both the trawl and trap surveys. There continues to be a high level of variability throughout the inshore areas. Landings in 2011 more than doubled from 2010 to the highest point since 2006, due in part to the reopening of Bonne Bay after a two year moratorium. Harvesters are encouraged by positive signs of recruitment and the abundance of new-shelled crab observed from the post-season trap survey.

CONCLUSIONS AND ADVICE

Division 2H

The **exploitable biomass** is very low. **Recruitment** has decreased since 2004 and is expected to be low over the next several years. Long-term recruitment prospects are poor.

Division 2J

The **exploitable biomass** has decreased in recent years. **Recruitment** has recently been in decline and is expected to remain low in the short term. Long-term recruitment prospects are unfavourable due to a warming oceanographic regime. The **exploitation rate index** changed little in the past three years. The **pre-recruit fishing mortality index** has remained low in recent years, but increased to its highest level since 2004 during 2011.

Maintaining the current level of fishery removals would likely increase the **exploitation rate** in 2012.

Division 3K

Offshore

The **exploitable biomass** has declined by more than half since 2008. **Recruitment** decreased in 2011 and is expected to decrease further in 2012. Prospects remain poor in the short term. Long-term recruitment prospects are unfavourable due to a recent warming ocean climate regime. The trawl survey-based **exploitation rate index** declined sharply between 2006 and 2008 and has since increased back to the 2006 level. The **pre-recruit fishing mortality index** increased from 2007-2011.

Maintaining the current level of fishery removals would likely result in an increase in the **exploitation rate** and high mortality on soft-shelled immediate pre-recruits in 2012.

Inshore

The **exploitable biomass** decreased gradually between 2007 and 2010 and since changed little but there is considerable variability among management areas. While uncertain, **recruitment** prospects appear to have changed little and there is considerable variability among management areas. The trap survey-based **exploitation rate index** increased sharply in 2010 and then returned to the 2007-2009 level in 2011. Data are insufficient to estimate the **pre-recruit fishing mortality index**.

Maintaining the current level of removals would likely have little effect on the **exploitation rate** in 2012. However, it would likely result in increased wastage of soft shelled immediate pre-recruits in some management areas in 2012.

Division 3LNO Offshore

Opposing survey trends create uncertainty about the **exploitable biomass**. **Recruitment** has recently peaked and will likely decrease over the next two to three years. Long-term recruitment prospects are unfavourable due to a warming oceanographic regime. The

exploitation rate index increased in 2011 following a sharp decrease from 2008-2010 while the **pre-recruit fishing mortality rate index** has remained near its lowest level during the past three years.

Maintaining the current level of removals would have an uncertain effect on the **exploitation rate** in 2012.

Division 3L Inshore

The **exploitable biomass** has changed little over the past 6 years. Overall, **recruitment** prospects have recently improved. The trap survey-based **exploitation rate index** decreased slightly in 2011. Data are insufficient to estimate a **pre-recruit fishing mortality index**.

Maintaining the current level of fishery removals would likely result in little change in the **exploitation rate**, but may increase mortality on soft-shelled immediate pre-recruits in some areas in 2012.

Subdivision 3Ps

Offshore

The **exploitable biomass** increased steadily from 2006-2009 and has since declined sharply to 2011. **Recruitment** has recently declined and is expected to decline further in the short term. Long-term recruitment prospects are unfavourable due to a warming oceanographic regime. **Exploitation and pre-recruit fishing mortality rates**, as indicated by spring trawl survey indices, decreased from 2007-2009 but increased sharply to 2011.

Maintaining the current level of fishery removals would likely result in an increase in the **exploitation rate** in 2012.

Inshore

The **exploitable biomass** increased substantially between 2006 and 2010 and decreased in 2011. **Recruitment** decreased in 2011 and is expected to decrease further in the short term. The post-season trap survey-based **exploitation rate index** changed little during 2008-2011. Data are insufficient to estimate a **pre-recruit fishing mortality index**.

Maintaining the current level of fishery removals would likely result in an increase in the **exploitation rate** in 2012.

Division 4R

Offshore

The **exploitable biomass** remains low. **Recruitment** has been low in recent years and prospects are uncertain. Data are insufficient to calculate **exploitation rate** and **pre-recruit fishing mortality indices**.

The effect of maintaining the current level of removals on the **exploitation rate** in 2012 is unknown.

Inshore

The post-season trap survey **exploitable biomass** index changed little from 2005-2009 but has increased greatly in the past two years. **Recruitment** has recently increased and short-term prospects remain promising in most management areas. The post-season trap survey-based **exploitation rate** index decreased from 2007-2010 but increased sharply in 2011.

Increasing fishery removals in 2012 would likely have little effect on the **exploitation rate** but may increase mortality on soft-shelled immediate pre-recruits in some management areas.

OTHER CONSIDERATIONS

Reproductive Biology

The percentage of mature females carrying full clutches of viable eggs has generally remained high throughout the time series.

Fishery-induced mortality on undersized males may adversely affect insemination of females, especially when abundance of larger adults is low.

Bitter Crab Disease (BCD)

This disease, which is fatal to crabs, occurs in new-shelled crab of both sexes and appears to be acquired during molting. There had been a broadly-distributed incidence of **bitter crab disease** during 1996-2006, but the distribution contracted primarily to Div. 3K in 2007. Prevalence has changed little overall, remaining low, in recent years.

Effects of predation

An investigation of the possible effect of predation by cod showed that snow crab was virtually absent from the diet in the past three years based on analysis of stomachs from the fall multi-species surveys in Div. 2J3KLNO. Analysis of stomachs from the sentinel survey in the inshore showed minimal predation on crab, especially in Div. 3K. Much lower predation by cod in recent years relative to the 1980s-early 1990s was attributed to the reduced abundance of large fish (>50 cm) that historically accounted for most of this predation.

Utility of Small-meshed Traps

An investigation was conducted on the utility of small-meshed traps used in the CPS survey in providing a useful index of recruitment. It was found that these traps can reliably identify recruitment signals based on progression of adolescents through the size frequency distributions. The present assessment was the first to provide an indication of long term recruitment prospects based on the information from small mesh traps as well as the effects of oceanographic variation on survival during early life stages.

Management Considerations

The development of relationships between biomass indices and ocean climate indices provides the basis for some long-term recruitment prediction. A warming oceanographic regime in recent

years suggests unfavourable recruitment for up to 6-8 years. If a warm regime persists, as expected (Colbourne et al. 2012), poor recruitment can be expected in the longer term.

Reproductive potential is largely protected by conservation measures that exclude females and males smaller than 95 mm CW, including a portion of the adult (large-clawed) males, from the fishery. Therefore, exploitation has been considered to have minimal impact on reproductive potential. However, fishery-induced mortality on small (<95mm CW) males may adversely affect insemination of females, especially when abundance of larger adults is low.

Fishery-induced mortality on pre-recruits can impair future recruitment. Pre-recruit mortality is reduced by avoidance in the fishery and, when encountered, careful handling and quick release of pre-recruits. Mortality on sub-legal-sized males, including adolescent pre-recruits, can also be reduced by increasing trap mesh size and soak time, as well as trap modifications such as escape mechanisms. Such initiatives have reportedly been increasingly implemented in recent years. Use of biodegradable panels can also reduce mortality associated with ghost fishing (lost traps).

Prevalence of soft-shelled legal-sized males in the fishery is believed to be a function of both fishery timing and exploitable biomass level. Mortality on soft-shelled males can be minimized by fishing early in spring before recently-molted crabs are capable of climbing into traps. It may be further reduced by maintaining a relatively high exploitable biomass level, thereby maintaining strong competition for baited traps and low catchability of less-competitive soft-shelled immediate pre-recruits.

There is concern that mortality on soft-shelled immediate pre-recruits has increased in Div. 3K in recent years due to declining exploitable biomass. If prevalence of soft-shelled crab is widespread then the current soft-shelled protocol would not likely provide adequate protection of immediate pre-recruits. Measures should be taken to ensure representative observer coverage so as to better quantify soft-shell prevalence in the fishery. Meanwhile, it would be precautionary to reduce the exploitation rate so as to promote recovery of the exploitable biomass.

SOURCES OF INFORMATION

This Science Advisory Report is from the February 21 – 24, 2012 regional peer review process on the Assessment of Snow Crab. Additional publications from this process will be posted as they become available on the DFO Science Advisory Schedule at <http://www.dfo-mpo.gc.ca/csas-sccs/index-eng.htm>.

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